Practical Incremental Application of Process Improvement, Optimisation and Manufacturing theories in Small to Medium Enterprises (SMEs)

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This work or any part thereof has not previously been presented in any form to the University or to any other body whether for the purposes of assessment, publication or for any other purpose (unless otherwise indicated). Save for any express acknowledgments, references and/or bibliographies cited in the work, I confirm that the intellectual content of the work is the result of my own efforts and of no other person.

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Abstract

Due to rapidly changing and highly competitive nature of today's market place, manufacturing companies now recognise that survival and profitability are functions of continuous improvement. High quality and reliable products must be produced and delivered at lower cost than the competition. This has led to adoption of a range of time and quality based competitive paradigm/programmes such as Zero Defects, Lean Manufacturing, Six Sigma, JIT, SMED, etc. Evidence from many large Japanese companies and others large companies in the EU and USA showed that these programmes contribute substantial benefits. However, in the case of SMEs, proofs of such successes are scant. Factors such as lack of resources, knowledge and culture are some of the factors shown to be militating against SMEs. By extension, it can also be argued that such factors are the main grounds why SMEs have problems adopting and implementing improvement programmes because improvement programmes require time, money and knowledge. This research focused on how to evaluate and assist SMEs to achieve the most out of existing resources, and hence become more competitive, using a case study company as an implementation and validation platform.

A framework for achieving process improvement despite limited resources and resistance to change was demonstrated utilising widely available and often inexpensive tools. The main outcomes of this study include a £4 per unit cost reduction and more than 54% increase in capacity, and actual increase in sales of those products affected by the project of £868000. Other outcomes include productivity increases and stabilisation of lead times, knowledge-capture, and development of in-house MRP spread sheet and standard times to help with accurate product costing, culture change, reduced space requirement and production process layout. Most significantly the study established a new empirical stage on which others can build upon and understand how to implement process improvement in SMEs. Specifically, sensitivity to an organisation's environment

and its politics as essential ingredients, must accompany World Class Manufacturing techniques.

Table of Contents

List of Figures

List of Tables

List of Pictures

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Chapter 1

Background to the research and statement of the problem

1.1 Statement of the Problem

The need to improve the core activities, which generates an organisation's goods and services in order to ensure profitability, is not new. A rapidly changing business environment, globalisation and ever more demanding customers have now made it virtually impossible for manufacturing companies to survive and make profit without continuously improving their process (de Jager *et al.*, 2004), (Lee and Chuah, 2001). In addition to quality products, which must be produced and delivered at low cost, manufacturing companies must also make and deliver its product faster than the competition.

This competition also dictates that companies must find and use more sophisticated methods. In order to achieve this difficult combination, many organisations are now embracing various time as well as quality based competitive concepts such as Lean Manufacturing, Six Sigma, Just-In-Time (JIT) or Non Stock Production (NSP), and Single Minute Exchange of Die (SMED) (Hum and Sim 1996).

There is no doubt that substantial gains can be made by adopting these programmes as evidenced by many large Japanese companies (Kazazi and Keller, 1994). These Japanese companies such as Toyota succeeded where their counterparts in the US and Europe failed thus earning themselves the status of "best in their class" or World Class Manufacturer (Flynn *et al.*, 1997).

The 1980s saw many companies copying and imitating these successful Japanese manufacturing practices. JIT, Quality at Source, Kanban, Quality Circles, Flexible employees, and Single Minute Exchange of Dies (SMED) became the buzzword amongst many companies. Evidence suggests that many companies achieved substantial success as a result of these improvement methods. But Gaither and Frazier (Gaither and Frazier, 1999a) have this to say, "…Merely copying the operational tactics of other companies is not enough to succeed in a competitive industry…". Both operational effectiveness and good strategy are essential for superior business performance.

Another problem is the level of resources required to implement any of these methods. Improvement programmes require resources such as time, finance and personnel. But, it is well known that lack of resources, knowledge, and organisation culture issues are some of the main factors militating against SMEs (Wong and Aspinwall, 2004b). Hence, it is not surprising that there are not as many cases of successful adaptation, implementation and sustenance of world-class improvement programmes by SMEs in literature.

What works for large companies may not be appropriate for SMEs since in most cases the two differ in structure, resources available and culture. However, while SMEs might differ in terms of structure and available resources, their problems and business objectives are fairly similar. They both face intense and capable competition and both need to innovate in order to survive and make profit. In most cases, SMEs have no choice but to implement these new methods. For example, many large car manufacturers insist that their suppliers who are often SMEs implement quality initiative such as ISO 9000, TQM, Supplier Quality Assurance and so forth (Yusof, 2000), (Yusof and Aspinwall, 2000b). In any case the performance of suppliers is crucial to the performance of large manufacturers (Lee and Oakes, 1995).

Unlike earlier times, SMEs must now reduce their lead-time and operate flexible manufacturing practices if they want to carry on doing business with the JIT practicing large companies. SMEs particularly those in the West are under pressure to streamline their operations, reduce costs and prices. National boundaries can no longer provide any protection. Taiwanese, Korean, Japanese and other Far East companies have not only invested in modern production technologies but enjoy enormous cost advantage compared to companies here in the UK.

So, gone are the days of high volume standardised products using, large batch size, and large inventory, using mainly low skill work force and single purpose machines. Nowadays, even for SMEs the focus must be variable volumes, one-piece flow, reduced inventory, short lead times and continuous improvement.

1.2 Research objective

The research started by reviewing the basics of Process Improvement and the SMEs, the aim being to extract those factors that are important for implementing Process Improvement in SMEs. This is important because as already mentioned, what works for one company may not work for another and since SMEs have scant resources, they do not have enough resources to embark on experiments.

A case study company, (a medium sized enterprise based in Shropshire) was used as an implementation and validation platform to evaluate how to assist SMEs to achieve the most out of existing resources, and hence become more competitive. These include culture change within the workforce, equipment, staff issues and space utilisation. This was carried out under the auspices of the Knowledge Transfer Partnership (KTP) between Wolverhampton University and the case study company. Due to the size of the company, constrained resources and the predicted resistance to change, implementation logically must be incremental. Based on the aforementioned literature and academic theories, various process improvements, optimisation and manufacturing techniques will be utilised towards carrying out the following tasks:

- Full review of the case study manufacturing processes.
- Workflow plans for each product.
- Increase productivity and reduce lead times.
- Recommendations for Capital equipment upgrade.
- Develop standard times to help with accurate product costing.

- Formalise the production process layout.
- Initiate culture change by instituting multi-skilling and development of the operatives.

Naturally, all these tasks are aimed at helping the company to reduce its operating costs and become more competitive. Thus, specific research questions addressed by the research include:

1. Can the established Production and Operations Manufacturing strategies be applied successfully to SMEs such as the case study company?
2. If yes, what is the criteria to evaluate whether the strategies are successful or not for process improvement?
3. Can the lessons learnt from this case study be used as a framework for achieving improved process and competitive advantage by other SMEs?

Ultimately, the chief aim of the study is to help create a lot more “success stories” of successful implementation of World Class Manufacturing (WCM) methodologies in SMEs, which is scant at the moment. And in doing so help demonstrate a “how to” approach for other SMEs. It is recognised that one size cannot fit all but mistakes and successes made by the research will surely be of benefit to other SMEs. The SMEs are very important, economies and large companies depend on them; they provide the highest number of jobs in both developed and undeveloped economies.

1.3 Outline of the thesis

The thesis consists of 8 chapters. Chapter one provides an introduction and determined the basis of the research. Relevant research question were addressed as well as some of the main tasks of the research. This is followed by a description of the methodology adopted by the research.

Chapter 2 started by presenting brief historical background of Process Improvement, some academic theories, optimisation and manufacturing techniques.

In chapter 3 the focus shifted to characteristics of Small to Medium sized Companies and pertinent literatures contributed by others are reviewed. A framework for achieving process improvement in SMEs with limited manufacturing experience was proposed and discussed. The case study company is introduced including opportunities and the problems it faced. The various tasks and how they were tackled are then presented; the groundwork done on the company's four main subcomponents namely the company's business process, the Manufacturing Shopfloor, and the Assembly Shopfloor are developed.

Chapter 4 covered the initial study conducted to examine the case study company's overall business process. This includes an examination of how all the various teams actually interact to produce and deliver the company's goods and services. Chapter 5 covered work done on the manufacturing shopfloor; this area is very important to the company and comprised the critical work performed by the research study for the company. Chapter 6 presented work done on the Assembly shopfloor.

The final chapter, chapter 7 and chapter 8 culminate the report; the two chapters highlight the main outcomes of the project and provide a discussion about contribution to the field. Finally, the limitations of the research and possible future work were also outlined.

1.4 Research methodology

According to Yusof and Aspinwall (Yusof and Aspinwall 2001) a case study as a research strategy can be used when attempting to comprehend multifaceted organisation problems. In other words it enables one to locate something, which is sufficiently manageable and can be understood in all its complexity. There is abundance of successful deployment of this strategy in literature (Kasul and Motwani, 1997), (Mei *et al.*, 2007), (Lewis, 2000).

The case study company did not desire what they termed “one size fits all solution” and use of external consultant who they suspect might just administer “quick fix” solution without understanding or taking the firm’s unique structure and needs into consideration. What they required was a hands-on approach to problem identification, analysis and solution finding. Hence, for the purpose of achieving the aims of the research project participatory action research methodology was used. Action research is defined as “the application of scientific method of fact finding and experimentation to practical problems requiring actions and involving the collaboration of scientists, practitioners and laymen” (French and Bell, 1973). Quoting Pasmore and Friedlander (Pasmore and Friedlander, 1982), Gilmore and Smith (Gilmore and Smith, 1996b) highlighted the importance of action research particularly when pursuing Japanese style operational tactics, which promote “problem-solving by all organisation members, rather than just the traditional few at the top”.

In line with action research methodology, problems were identified in collaboration with the case study company. Next, the starting point for investigating the problem was ascertained and data collection with active participation of the case study company’s people started. The collected data were then presented to the stakeholders and appropriate action negotiated, agreed and implemented. Results were then monitored and analysed. This is essential for ensuring that good results are sustained and remain effective for a long time. The methodology is in line with Deming’s vision of a system whereby feedback from the customer and process are appraised against organisational goals in a repeating circle of Plan-Do-Study-Action (PDSA) or Plan-Do-Check-Action (PCDA). And it is similar to Six-Sigma process improvement characterised by the DMAIC method - Define, Measure, Analyse, Improvement, and Control (Eckes, 2000).

Data were collected via interviews, and participative observation. In addition, the author maintained a diary, which recorded daily involvement in both formal and informal meetings with the production operatives, weekly and monthly project review meetings between the case study company Managing Director, the Operations

Director and the University Academic Supervisor. Collected quantitative data were analysed using simple descriptive statistics.

Three levels of meetings are held to control and monitor project progress. These include daily informal contacts with the company Supervisor and other stakeholders, monthly review meetings and the Local Management Committee meetings (LMC).

The Author holds ad hoc weekly meetings with the academic supervisor. Project review meetings are held monthly (later bimonthly) between the author, the Supervisors and the MD of the case study company. Local Management Committee, which is meeting of all major stakeholders were held every quarter.

The case study company MD chaired the monthly meetings while the Author was responsible for organising the meetings, preparing agendas, taking minutes and for distributing them. Meeting minutes were comprehensive, and served the purpose of formally communicating the project progress, tasks and exceptions.

Note: Specific and detailed information regarding the case company's processes such as costs, and operation times have been redacted to protect confidentiality and other sensitive information after consulting the company's MD.

Chapter 2

Historical Background of Process Improvement – Literature Review

2.1 The industrial revolution and interchangeable parts of the 1700s

Arguably, transformation of inputs into outputs now known as production is as old as man. And man, since history can remember have always been searching for a better way of doing things in the face of constraints. The evidence is all around us, and there are substantial payoffs for those who succeed. Modern living as we know it would not certainly has been possible without production and improvements to production processes.

Reference to the concept of Process Improvement dates back to ancient times, for examples it was said that the trigger of civilisation is the invention of the scratch plough (Burke, 1979). This was an improvement on the earlier method of using digging sticks. The scratch plough is significant because it is an instrument of surplus. It became a means of achieving mass production of food so that non-food producers can be supported. This in turn stimulated development of civilisation by supporting professions such as astronomy, mathematics, taxation, planning, etc.

The congregation of large number of workers due to commencement of factory system in England in the 1700s created the need for organising worker in logical ways to produce good (Gaither and Frazier, 1999b). The publication of Adam Smith's The Wealth of Nations in 1776 underpinned the economic benefit of **division of labour**. Shingo (Shingo, 1988b) described division of labour as "*the single most important development that revolutionised human productivity in the modern age*". Production of products are broken down into small but specialised tasks and assigned to workers along production lines. Adam Smith cited an example of pin production where using this method, ten men could make forty-eight thousand pins in a day or the equivalent of 4800 pins per person in a day. This is approximately double what a skilled worker working independently can produce in a day.

Another development of this era was the development of system of interchangeable parts or standardisation of parts. This was the first recorded time that parts were manufactured to a standardised pattern, so that a broken part could be replaced by another part that would fit perfectly, right the first time. The system of interchangeable parts combined into what became the American system of Manufacture and allowed a shift from one-at-a-time production to volume production of standardised products such as bicycles, locomotives, and ultimately the motor car, all made of interchangeable parts. All of these in turn advanced the need for measurement and inspection (Burke, 1979; Russell and Taylor III, 2000; Gaither and Frazier, 1999b).

2.2 Productivity and Scientific management

Fredrick Taylor popularised the notion of using measurement, analysis, observation and standardisation to determine the best method of performing a job. Taylor devoted two years studying the relationship between rest and fatigue when performing heavy labour and used his famous pig iron hauling experiment to prove that using scientific method a man's productivity can be increased more than four times. He also showed that assigning the right tool and person to a task could raise productivity 3.7 times (Shingo, 1988d). This philosophy became known as Scientific Management and was embraced by other experts such as Henry Gantt, Frank and Lillian Gilbreth (Russell and Taylor III, 2000; Reid and Sanders, 2002).

Arguing that "time is merely a shadow of motion" and that human motion is composed of 18 elemental movements, which they termed "**therbligs**" Frank and Lillian Gilbreth introduced Motion Study. According to them, a task takes long to complete because the motions required to perform it is long. Hence, provided improvements can be made to the work conditions that necessitated motions, the time taken to perform a task can be reduced (Shingo, 1988c).

Just like Taylor, Gilbreth outlined detailed rules on how to find out the one best way of performing a job. However, unlike Taylor they focused on the whole work environment not just on selecting the best worker. They made the working day shorter, brought in rest periods, chairs, holidays with pay, better ventilation and lightening, canteens and entertainment into factories. Using the famous brick laying task experiment, Gilbreth demonstrated that the eighteen separate movements (*search, find, select, grasp, hold, transport loaded, transport empty, position, assemble, use, disassemble, inspect, pre-position, release load, unavoidable delay, avoidable delay, plan, rest for overcoming fatigue*) ordinarily involved in the task can be reduced to just five and increased the bricklayers' productivity from 120 to 350 bricks per hour. Furthermore, in order to control work carried out on building sites far away from head office, Gilbreth devised 'the field system', which is a set of rules and procedures establishing uniform practice on all work sites. It detailed amongst other things how to transport materials, train apprentices, erect scaffolding, and so forth. Henry Gantts' main contribution is humanising Taylor's Scientific Management; Gantt believed that Scientific Management was being used as an oppressive instrument by unscrupulous management. He introduced task and bonus payment scheme. He also replaced the "one best way" with "best known way at present"(Huczynski and Buchanan, 2001d).

2.3 Ford and the Assemble line production

The assembly line production system is a testimony of the advantages of the Scientific Management movement. Fords' production method and assembly line personified the main elements of Scientific Management such as operation standardisation, cost reduction through adoption of better methods, division of labour and interchangeable parts. Jobs are analysed using time and motion techniques; the motion picture department filmed methods in different industries in order to learn from them, employees are given simplified and carefully designed tasks in order to ensure maximum efficiency. Skills are built in (often single purpose) machines rather than in people. In every way his assemble line demonstrated the way to mass-produce goods at reduced unit cost. Astonishingly, instead of the previous 728 hours required by a worker to assemble a Model T car, with the assembly line it took only 93 minutes (Gaither and Frazier, 1999b). By 1920, through the implementation of line balancing technique a Ford car came off the line every minute and by 1925 it became one every 10 seconds. Ford also established what can today be described as personnel department and paid higher wages than the going rate (Huczynski and Buchanan, 2001d).

2.4 Hawthorn studies and human relations movement

Although Scientific Management and Fords' system achieved very high level of productivity it was matched by a lot of negative reactions. It was accused of practicing authoritarianism, closely monitored short-cycle, and machine-paced, unremitting as well as deskilled work. Consequently, the company experienced very high worker turnover at a cost of more than $3 million a year (Wilson, 1995a). Workers simply walked off without any warning and were only attracted back when Ford reduced working time from 9 hours to 8 hours and started paying twice more than any other motorcar company (Huczynski and Buchanan, 2001d). The salient point here is that perhaps Taylorism in its pure sense does not have all the answers.

The concept that relationship at work can impact on worker performance can be traced to Hawthorne experiments (illumination, relay assembly test room experiments, interviewing programme, and Bank Wiring Observation Room experiment) of the 1920s and 1930s. The experiments showed that productivity can be affected by simply making a group of workers an object of attention (i.e. being observed by friendly researchers) and not dependent on variables such as hours of work, and breaks for refreshment. Thus was born the concept of Hawthorne effect. Bank Wiring Observation Room experiment found that informal organisation control outputs and that not even the opportunity to earn more money can entice team members to produce more than the output rate agreed between members of the informal organisation. This is because the informal organisation operates under a norm rigorously enforced. The norms include: Not to turn out too much work (rate buster); neither should too little work be turned out (Chiseller); get a colleague into trouble by talking to a supervisor (squealer); not maintain social distance for example an inspector should not act like one.

The fundamental lessons (Huczynski and Buchanan, 2001b) that can be drawn out of the Hawthorne studies include:

- “Work is a group activity and workers are not machines that can be manipulated and adjusted to shape a company’s performance.
- Participation, consultation and feedback improve productivity.
- Less intense form of supervision reduces stress and hence can improve productivity.
- Giving people status and recognition can have a motivating effect. Recognition, security and sense of belonging are a more important determinant of worker’s productivity and morale.
- A friendly atmosphere can improve morale.
- Allowing workers autonomy in the selection of their team can create higher levels of mutual dependence and support, which is a requirement for group working.
- People are motivated by more than just pay and conditions. The ability of the informal group to motivate individuals should not be underestimated due to its power.
- Supervisors need to be aware of both individuals’ social needs and the needs and power of the informal group in order to align these to achieve the formal objectives”.

The inferences and salience of Hawthorne Studies have been supported by several other studies highlighting the dehumanising effect Scientific Management method can have on workers and the ingenious ways workers use to resist and survive it. For example, William Thompson (Thompson, 1983) declared after working with and observing assembly line workers in a beef-processing plant that “working in a beef pant is dirty work, not only in a literal sense of being soaked with perspiration and beef blood, but also in the figurative sense of performing a low status, routine and demeaning job”. Charles Walker and Robert Guest (Walker and Guest, 1952) argued that certain production technologies prevent formation of workgroups thus frustrating social needs of factory workers. Their study showed that despite good working conditions, employees in jobs with high mass-production score dislike those aspects of their work and had high absenteeism than those in low scoring jobs. This line of thought was further expanded by Morris Viteles (Viteles, 1950) and Karasek (Karasek, 1979), their study argued that the blend of increased mechanisation with scientific management created routine, repetitive tasks leading to monotony and boredom, which in turn reduced work rate, output, morale and led to high levels of absenteeism, complaints, exhaustion and depression.

These conclusions were the launch pad that kicked off **Human Relations and Behaviourists' movement,** and culminated in the works on motivation theories of Maslow, Herzberg, McGregor, Drucker and others. They showed that creating an enabling atmosphere could be used to tap into great potentials of industrial workers. To a large extent this is still valid even till today.

2.5 Time based competition - Lean and Just-In-Time (JIT) Manufacturing

Swedish carmakers Saab-Scania and Volvo were among the first to recognise that the monotony and boredom characterised by Scientific Management mass production could be reversed by creative work design using job rotation and enlargement. Workers were divided into production groups and group members were responsible for deciding how tasks were rotated as well as maintenance and quality issues. Volvo pioneered the concept of dock assembly. Teams completed whole stages of the final car assembly process in bays to one side of a moving assembly track. The results were improved productivity and product quality. Saab reported costs reduction of 5% below budget; labour turnover reduced from 70 to 20%; relationship between management and the workforce improved even though absenteeism was not affected. In 1974, Saab estimated that the approach saved it 65000 Swedish Kronor per year on recruitment and training cost alone. However, the success of the Swedish carmakers did not last very long. Following the closures of some Saab and Volvo factories and finally, takeovers by American companies in the 1990s, the popularity of team-based manufacturing was tarnished (Huczynski and Buchanan, 2001c). Ironically, as the Swedish companies were losing businesses, selling and closing their factories, Japanese companies such as Toyota and Nissan were attaining unbelievable success. The Japanese advantages were due to application of best practice, which has come to be personified by Lean manufacturing method (Womack *et al.*, 1990).

Lean Manufacturing has come to epitomise Hayes and Wheelwright's World Class Manufacturing (Hayes and Wheelwright 1985). While Lean Manufacturing is not the only World Class Manufacturing (WCM) method (for examples, we have Six Sigma, MRP, MRPII, SPC, TOC, FMS, CIM amongst others), its central tenets speaks of things that are central to the competitiveness of many manufacturing companies. The next section will survey earlier studies of best practice and WCM.

2.5.1 Compressing time

References to the term "best practice" are by no means scant. It has become a catchphrase used by both academics and the industrialist as demonstrated by the significant percentage of recent literature in the areas of business and manufacturing, which makes references to best practice (Heibeler *et al.*, 1998). This is buoyed up by intensive search by a lot of companies seeking to attain WCM status. Best practices are usually associated with those practices that enables an organisation to be better or equal to similar organisations (Heibeler *et al.*, 1998). Davies and Kochhar (Davies and Kochhar, 2002) in their critique of manufacturing best practice and performance agreed largely that best practice should lead to higher performance. However, they pointed out that in most studies the links between practice and performance are too broad in nature, to offer proper cause and effect analysis of the impact of practices on performance. They then went on to argue that best practice should be "context specific"; they put forward the International Quality Study's definition of best practice as a better one. International Quality Study defined best practice as "those that have aided the lower performing companies to improve to medium performance, medium performers improve to higher performers, and higher performers to continue to be successful and achieve further benefits (International Quality Study, 1993).

The most popular studies over the last decades about best practice have usually been based on Japanese Lean manufacturing system. They include for examples Womack and Jones's The machine that changed the world (Womack *et al.*, 1990), Lean Thinking (Womack and Jones, 1996), and Julian Page's Implementing Lean Manufacturing Techniques (Page, 2004). The main reason for implementing Lean according to Sriparavastu and Gupta (Sriparavastu and Gupta, 1997) is to increase productivity, reduce lead times and costs, improve quality, etc. The method employs (Sánchez and Pérez, 2001; Page, 2004; Heizer and Render, 1993; Carreira 2005):

- Elimination of zero-value (waste) activities: Lean defines waste as anything that does not add value to product and services. These include defects in products, overproduction, work in progress, unnecessary processing, unnecessary motion/movement, excessive transportation, and idle or waiting people. They form the seven wastes and are targeted for elimination.
- Just in time delivery of materials is an implied component of Lean; parts are supplied just at the right quantity and the right time to avoid waste. Since inventory is reduced then a Lean environment will experience reduction in space requirement. Just in time delivery also demands integration of suppliers.
- Flexible information system.
- Placing responsibility on workers to improve production tasks.
- Continuous improvement: It requires involvement of everyone in the company and maximum support of top management. As soon as a worker identifies an improvement, this is agreed with supervision and engineering staff and the standard work sheet revised to include the "new best way".
- Aggressive problem solving using quality circle.
- Set up reduction and elimination of defect. The whole plant can be halted in order to solve a problem. Consequently, lot sizes are greatly reduced in a Lean environment thus helping to cut lead-time and enhance flexibility in responding to customer requirements.
- Powerful first line supervisors who monitor and encourage continuous improvement.

In the past, manufacturing quality products at low cost were enough to assure success but that is no longer the case today. Today, companies must not only produce quality products at the lowest cost, they also need to be the fastest in getting them to the customer. In traditional manufacturing, capacity utilisation was high and production cost low but this results in large in-process inventories and consequently long lead times. Lean Manufacturing uses Single Minute Exchange of Die (SMED) to reduce setup times and hence remove the rationale for large lot sizes. The outcome is not only shortened order-to-delivery-cycle but also better workflow and greater flexibility. Common sense suggests that where two companies were in competition; the one that will win is the one that has good, low priced, quality products, and is able to deliver earlier than the competitor.

Chen and Kleiner (Chen and Kleiner, 2001) studied the significance of cycle time as a means of attaining improved profitability, higher levels of customer satisfaction, and increased market share. Their research examined several approaches to cycle time reduction that were actually implemented by some companies such as Xerox, Amstan, and American Standard. Their study highlighted how use of economic batch quantity was common among many manufacturing companies because it reduces product cost even though it increases cycle time. However, problems arose when customers started demanding shorter delivery times and were able to get them from competitors. Interestingly, their study showed that those firms with shorter cycle times did not achieve it by slashing inventories and investing in new technologies alone. Instead, such companies recognised that “as many as 90% of existing activities are non-essential and can be eliminated”. For example by eliminating wastes associated with changeovers, quality defects, process control, factory layout, machine downtime and scheduling. Three important lessons emerged from this study:

1. Competitive advantage can be achieved by organizing production lines to make every model every day using pull system accompanied by continuous improvement (CI) and by using flow process because it makes everything (e.g. bottleneck, downtime, etc.) visible.
2. BPR is neither easy nor intuitive and should only be attempted with upper management full commitment.
3. Answers as to how to reduce cycle time does not rest on one approach; instead organisations should use an amalgamation of approaches to grow a system that

> is most relevant to needs unique to that organisation. It is also important not to rely only on reducing manufacturing cycle times; other components of the business function such as customer's purchase order processing, which can often be longer than manufacturing cycle time should be addressed.

The above inferences were also in agreement with the views of Motwani and Mohamed (Motwani and Mohamed, 2002). In their words, "despite the huge investments in information technology, new systems, and equipment, many companies have not improved their market responsiveness or operating efficiencies". They put Lean Manufacturing (also called Flow Manufacturing) forward as a system that holds the best promise for achieving process improvement. Using a case study of flow manufacturing implementation at ACME to highlight the necessity and benefits of the system, they reported a lead-time reduction from 22 days down to 7 days (68% improvement), quality improvement of 62.5% (from 8% total defect down to 3%). They also showed that the company saved a lot of money as result of reduced work in progress and implementation of cell based production approach, which reduced transportation and so, a reduction in production time. Thus it can be surmised that Lean-manufacturing method has great advantages (flexibility, quality and productivity) over traditional methods and can be used to bypass competitors that have not fully grasped the philosophy.

However, these studies also showed that Flow should not be approached lightly since it requires significant changes in production process and employee training. In other words a Lean Manufacturing culture must be put in place beforehand. Indeed Lean have many critics, for examples it has been said that the much-vaunted emphasis on team working is not the same as the job enrichment approach made popular by Swedish companies. "There is evidence to suggest that Lean production is also mean production" (Huczynski and Buchanan, 2001c). The demands of Kaizen, supervisory regulation of methods and it's scientific management method stress inducing pace and intensity lead some scholars such as Parker and slaughter (Parker and Slaughter, 1988) to declare that success of lean is success based on "management by stress".

A second critic is that the success of the Japanese approach is culture dependent. Hence, Japanese companies have not always been successful in turning its workforce outside of Japan into Japanese type workers. “The evidence indicates that the transferability of these methods to environments outside of Japan has been sometimes problematic” (Daniel and Reitsperger, 1996). Shingo, the man credited with invention of the many tools used by Lean such as SMED narrated the experience of three Japanese joint venture companies in Mexico and UK (Shingo, 1988). One of the Mexican companies did not do very well because it simply adopted Japanese method and expected some voluntary inputs from the workers. The other company did well after checking and improving all operations then established standard procedures; the workers faithfully followed what they were taught even though they did not voluntarily propose or make improvements on their own like Japanese workers would do. UK workers were found to behave similarly – loyal, reliable, will faithfully follow procedures but show no inclination to make improvements voluntarily. So, “when in Mexico behave like Mexicans”, counselled Shingo.

Thus, while accepting the universality of need for performance improvement amongst many companies, Lee and Chua (Lee and Chuah, 2001) sounded a note of caution. The complex nature and varying processes existing in organisations today, demand that how improvement is achieved can vary from company to company. This is in recognition that “circumstances will vary, hence answers will vary”. Their answer to this dilemma is a methodology called SUPER, which combined various elements of Continuous Process Improvement (CPI), Business Process Reengineering (BPR) and Business Process Benchmarking (BPB). They validated their framework by successfully implementing it at a medium sized Hong Kong based company. The amalgamated methodology was particularly successful at reducing negative impacts of change. As will be seen later, reducing negative impacts of change is a very important consideration for small medium-to-medium sized enterprises (SMEs).

2.6 Conclusion

The methodology advocated by scientific management such as division of labour, job analysis and timing can actually improve productivity but one also need to be careful as to how far to take it. A machinelike organisation where people are simply cogs carrying out their carefully prescribed task, using their prescribed authority, to achieve worked organisation goals of efficiency and profits have been shown to be simplicity. It needs to be balanced with peoples' need for belonging, security and satisfaction in their job. Hence, enlarging jobs and empowering people to continuously improve their process should ameliorate scientific management methods. The panacea does not lie in job enlargement alone as have been demonstrated by problems experienced by Swedish companies. Lean techniques alone are also not the solution; in fact blindly copying the Japanese system of Kanban, etc. has been shown to be counterproductive. Taiich Ohno and Shigeo Shingo took up to 30 years to develop and implement Lean Manufacturing at Toyota. The Lean tools are an assembly of solutions they implemented and refined over these period as a response to their companies requirement to draw materials just in time and deliver products to the customer exactly when required (just in time). Ohno and Shingo were not looking for one size fits all solution to every manufacturing problem. They just wanted to solve Toyota's problem. Reducing stock, driving down cost, just in time and reduction of lead times, and using less space makes sense. These are what every company desire and are achievable using Lean Manufacturing tools. Hence companies can certainly improve their processes using these broad based solutions but should remember that they may not necessarily apply in every situation.

Chapter 3

Focusing on Small to Medium Enterprises

3.1 Small to Medium Sized Enterprises (SMEs)

Definition of SMEs is quite contentious as evidenced by varying definitions in literature but a definition is required in order to show that lager and small businesses require different treatment. Most research into improvement programmes has mainly been focused on large companies (Cagliano and Blackmon, 2001). But it is important to be cautious when extrapolating and generalizing such results to SMEs; there is a general agreement that SMEs and large companies differ in terms of culture, identity, function, and customer response (Armitage, 2002). SMEs are not small versions of the larger ones. Bolton defined SME as an independent business managed by its owner or part owners and having a small share of the market (Bolton, 1971). In this paper however, the definition given by European Union and the Department of Trade and Industry, UK (Wong and Aspinwall, 2004b) which, defined an SME as a company employing less than 250 employees will be adopted.

Another important aspect is the characterisation of SMEs; this is important because it will help to better understand those key issues that would be required for implementing process improvement in an SME. Literatures, which identified the salient characteristics of SMEs, are quite abundant (Wong and Aspinwall, 2004b; Ghobadian and Gallear, 1997; Yusof and Aspinwall, 2000b; Lee and Oakes, 1995). These studies listed the characteristics of SMEs and their advantages and disadvantages with respect to the implementation of process improvement as follows:

Chief characteristics of SMEs:

1. Company usually started, owned and dominated by entrepreneurs.
2. Strategic process incremental and heuristic.

3. Modest management skills and competency by a highly visible and paternal management.
4. Structure is predominantly flat, simple and flexible. Closer and informal working relationship.
5. Managers wear multiple hats. There are no clear definition roles.
6. Company is mostly result oriented due to its entrepreneur nature and lack of resources. Low financial resources
7. Planning is simple; standardisation and formalisation is low.
8. Modest human resources; modest know-how with less expert professionals
9. Training and staff development is likely to be unplanned and small scale.
10. Customers and suppliers are likely to be known personally and socially.
11. Low degree of resistance to change
12. Low incidence of unionization

Advantages of SMEs with respect to implementation of process improvement:

1. Decision making is faster
2. Change implementation is likely to be easier
3. Better relation due to smaller number of people
4. Immediate feedback.
5. Unified culture.
6. Greater flexibility.
7. Visible presence of higher authority is likely to get things done.

Disadvantages of SMEs with respect to implementation of process improvement:

1. Owner Ethos; "know-it all" managers can stifle innovation and growth.
2. Lack of resources such as finance, knowledge and time can militate against process improvement requiring long-term commitment.
3. "Gut feeling" approach and lack of proper procedure can lead to wrong decision or at least not the optimal solution

From above summary, it is clear that SMEs and large companies have different characteristics; this also points to one of the reasons why success stories of SMEs implementing WCM improvement programmes are scant. Improvement programmes require time, finance, personnel, and enabling culture all of which are lacking in small companies.

A number of literatures argued that improvement programmes such as TQM is easier in SMEs since it is easier to implement change when fewer people are involved and since decision making lies with owner managers (Shea and Gobeli, 1995; Wessel and Burcher, 2004a). Furthermore, it was proposed that since SMEs have a more unified culture with fewer interest groups as well as simpler systems, processes and procedures implementation of WCM programmes should be quicker and easier (Wong and Aspinwall, 2004b).

However, these views were contradicted by the fact that SMEs seems to have less financial, technical, people (i.e. the problem of freeing up people from normal work without disrupting on-going processes), and knowledge pool (McAdam *et al.*, 2004, Lee and Oakes, 1995). This, in conjunction with views expressed by Ghobadian and Gallear (Ghobadian and Gallear, 1997) lead Wessel and Burcher (Wessel and Burcher, 2004a) to conclude that it is not proven that change is easier in SMEs. Indeed, unified culture and simple procedure is not the case with the case study company presented in this paper, since it's strategies as in Cagliano and Blackman's (Cagliano and Blackmon, 2001) paper "…has emerged through incremental learning process and tactical decisions, which are aimed at acquiring critical resources and building distinctive capabilities that are valued by customers, rather than being crafted through formal long-term planning process".

As will be seen in the subsequent section of this paper, the issues found at the case study company contradicted some of the identified characteristics of SMEs. Resistant to change was found as was divided culture and poor communication. What is not in doubt also is that despite literatures (Mazany 1995; Ong, 1997a; Patel *et al.* 2001) on issues facing SMEs, it is clear, that these studies have not sufficiently tackled specific and practical issues involved in implementing companywide process improvement programmes where employee resistance is an issue at an SME company with limited resources and manufacturing experience. Another important issue that was not adequately treated in literature is the issue of knowledge ownership and management, and how externalised knowledge can be used to gain improved overall business improvement in SMEs.

SMEs are very important to every economy (O'Regan and Ghobadian, 2004b), hence it is important that they must improve and innovate just like larger companies as they are particularly at risk given their lack of resources (Wong and Aspinwall, 2004b). To become more innovative, adaptive and intelligent, it is essential for any organization wanting to create and sustain competitive advantage to establish a mechanism for acquiring, sharing and applying knowledge since it is a strategic asset inimitable by competitors (Wong and Aspinwall, 2004b).

3.2 A framework for achieving process improvement in SMEs with limited manufacturing experience

Up to this point, this study has presented the evolution of process improvement, various effort as well as approaches over the years towards achieving sustained competitive advantage. The case has been made for adopting WCM tools embodied by Lean Manufacturing methodology. However, the study departed from the common approach by pointing out that SMEs such as the case study company presented in this paper require a different approach. The next logical question then is: what is the correct framework for achieving process improvement in SMEs with limited manufacturing experience and resources?

There have been a few attempts towards developing implementation framework but not ones appropriate for the needs of small businesses. This paucity was recognised by Sha'ri Mohd Yusof and Elaine Aspinwall (Yusof and Aspinwall, 2000a) when they complained that "*Of the implementation frameworks published in the literature, many had not been considered for applicability in small businesses*" and that the ones which have been proposed "*are too prescriptive, very much tool oriented and not detailed enough*". They then went on to develop a conceptual framework. However this concept remained a theoretical one not empirically tested in the field.

To answer the question presented above and fill this gap in the current research on process improvement implementation for small businesses, this study drew lessons from people described as improvement Gurus such as Philip Crosby, Armand Feigenbaum, Joseph Juran and W. Deming. Deming and Juran's work are presented below. Further lessons were extracted from other fields of knowledge such as Politics, Political Psychology, Industrial/Organizational Psychology, and Sociology Psychology.

3.2.1 Juran's work

The main contribution of Juran is managing for quality and the responsibility of senior management towards that end. He developed a cross-functional management approach that is composed of three managerial processes namely (Volker, 2001):

- Quality planning – establish customer needs, and then develop processes and products that will meet or exceed those needs.
- Quality control – this ensures that maximum process effectiveness or ensures that inherent process waste does not run out of control i.e. prevent adverse change. A team should investigate abnormal variation (i.e. sporadic spike).

The spike indicates that the waste is getting worst i.e. the process has moved beyond quality control limits.

- Quality improvement – processes need to be continuously improved by eliminating wastes however this will only happen through persistent seeking of “breakthrough”

Juran extended the Pareto principle to quality improvement issues i.e. 80% of the problem is caused by 20% of the causes. The principle reminds management to centre attention on the small 20% that are vital. He recognised cultural resistance (or human relations problems) as the root cause of quality problems and defined the following 10 step approach to quality improvement:

1. Build awareness of the need and opportunity for improvement
2. Set goals for improvement
3. Organize to reach the goals
4. Provide training
5. Carry out projects to solve problems
6. Report progress
7. Give recognition
8. Communicate results
9. Keep score
10. Maintain momentum by making annual improvement part of the regular systems and processes of the company.

3.2.2 William Edward Deming

Deming is widely recognized as the man who made huge impact to Japanese manufacturing and businesses by teaching and disseminating Shewhart's statistical control techniques. Deming’s key idea is that the onus is on management to continually improve the system as a whole not just the subcomponents such as machines and workers. He showed that understanding the various causes of variation (special and common causes) is required before real improvements can be made. Special causes include anomalies or one-off events; for example a company’s daily output suddenly dropped from the usual 40 units to 37. An investigation was conducted and it was found that the drop in capacity was caused by a newly employed and improperly trained worker and a faulty machine that required servicing. Training the new worker and servicing the machine soon restored capacity to the usual 40 units per day (Deming, 1986; Volker, 2001). The new worker and the faulty machine are special causes. Since this system is stable, the company can only improve further (say from 40 to 50 units) by investigating common causes of variation that hinders it and removing them. This is similar to hunting down and elimination of waste in Lean Manufacturing. Such wastes can be for example bad plant layout, poor choice of process, or time wasted setting up machines. Shouting and cajoling the workers through slogans, piece rate payment, target setting, etc. are unlikely to yield required result. A stable system does not require any goal to be specified since it will deliver that which it is capable of delivering. Any goal beyond the capability of the system will not be accomplished. Management have to take the lead in removing the common causes that makes it impossible for production workers to turn out good work. The obstacles that prevent the worker from taking pride in his or her work must also be removed. Deming noted that productivity is widely misunderstood by managers, academics and workers. To workers, increased productivity carries with it the threat of layoffs. "Managers understand productivity to be an economic trade-off between efficiency and product quality".

The 14 Points for Management shown below were offered by Deming as key principles for transforming business effectiveness (Deming, 1986; Volker, 2001).

1. Create constancy of purpose toward improvement of product and service, with the aim to become competitive and stay in business, and to provide jobs.

2. Adopt the new philosophy - management must awaken to the challenge, learn their responsibilities, and take on leadership for change.

3. Cease dependence on inspection to achieve quality. Eliminate the need for inspection on a mass basis by building quality into the product in the first place.

4. End the practice of awarding business on the basis of price tag. Instead, minimize total cost. Move towards a single supplier for any one item, on a long-term relationship of loyalty and trust.

5. Improve constantly and forever the system of production and service, to improve quality and productivity, and thus constantly decrease cost.

6. Institute training on the job.

7. Institute leadership - the aim of supervision should be to help people and machines and gadgets to do a better job. Supervision of management is in need of overhaul, as well as supervision of production workers.

8. Drive out fear, so that everyone may work effectively for the company.

9. Break down barriers between departments. People in research, design, sales, and production must work as a team, to foresee problems of production and in use that may be encountered with the product or service.

10. Eliminate slogans, exhortations, and targets for the work force asking for zero defects and new levels of productivity. Such exhortations only create adversarial relationships, as the bulk of the causes of low quality and low productivity belong to the system and thus lie beyond the power of the work force.

11. a. Eliminate work standards (quotas) on the factory floor. Substitute leadership.
    b. Eliminate management by objective. Eliminate management by numbers, numerical goals. Substitute workmanship.

12. a. Remove barriers that rob the hourly worker of his right to pride of workmanship. The responsibility of supervisors must be changed from sheer numbers to quality.
    b. Remove barriers that rob people in management and in engineering of their right to pride of workmanship. This means, *inter alia*, abolishment of the annual or merit rating and of management by objective

13. Institute a vigorous program of education and self-improvement.

14. Put everyone in the company to work to accomplish the transformation. The transformation is everyone's work.

In addition to the 14 Points, Deming also presented issues, which may prevent companies from realising the benefits of the 14 Points. He called these Diseases and Obstacles. They include amongst others Lack of constancy of purpose; emphasis on short-term profits; evaluation of performance, merit rating or annual review; mobility of management, job hopping; management by use of visible figures with little or no consideration of figures that are unknown or unknowable; expecting quick results without effort and sufficient education; relying on automation and machineries to solve problems, seeking examples to follow instead of developing solutions he particularly bemoaned copying of Quality Circles, Kanban, JIT, etc.); making excuses such as "Our problems are different", "Our quality control department takes care of all our problems of quality", "Our troubles lie entirely in the workforce", etc. (Deming, 1986; Volker, 2001).

Deming attributed the original idea for the PDCA or PDSA Cycle to Walter Shewhart. It provides a framework, which can be used to guide system process improvement or just a stage in the improvement process. The popularity of PDSA hinges on its simplicity; it provides a repetitive process to determine the next course of action when trying to accomplish the transformation emphasized by the 14 Points, or as a procedure for improvement of any stage or for finding a special cause detected by statistical signal. As shown below (**figure 2**), the PDSA Cycle can be viewed as a series of cycles representing the spirit of continuous improvement.

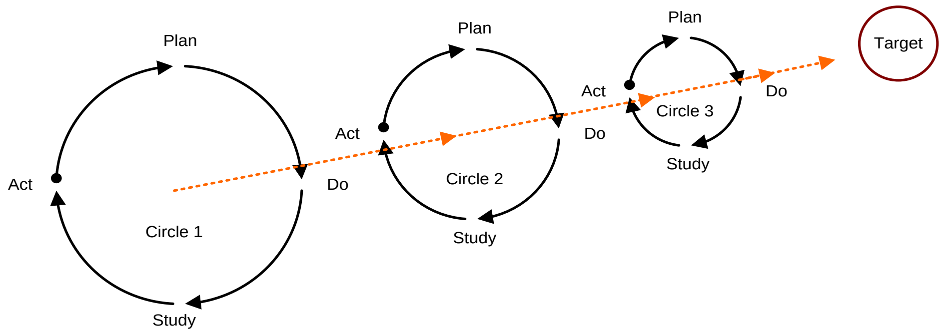


Figure 1: Interpretation of Deming's PDSA Cycle

Starting from cycle 1, what needs to change or improved are examined and planned (Plan). Next, the change decided upon is carried out (Do), preferably on a small scale. Then, the effects or results of the change are studied (Study) or measured to ascertain whether intended benefits are being realised. Finally, decide (Act) what to do with the change. For examples, abort the change, run the test again, adopt the change, etc. In cycle 2, the sequences of PDSA steps are repeated but using inputs and knowledge gained from cycle 1. Cycle 2 naturally flows into cycle 3, and so forth (toward the target position) with lessons learned at the end of one cycle being the starting point for the next more complex cycle.

The methodology advocated by Juran has much strength, for example it is structured and easy to understand. However, it demands resources such as trained personnel (e.g. statistician), which may not be available to small companies. Also, it requires commitment to the programme over a longer term; this is a risk that smaller firms may not be able to shoulder. Both Deming and Juran recognised that most of the possibilities for improvement lie in action on the system, which belong to management. And they both taught that for improvement of quality and productivity to be successful in any company, it must be a learning process, year by year, with top management leading. In the New Economics for Industry, Government, Education Deming proposed his **System of Profound Knowledge –** to transform an organisation successfully a thorough understanding of four components namely an appreciation for system, knowledge about variation, the theory of knowledge and an understanding of psychology (Deming 1993). In other words, successful change depends on recognising the organization environment as a system of interdependent parts, understanding the nature of variation within and among those components and comprehending the psychology, which compels the humans that make up the system. The psychology, which compels the human beings that make up a system, will be discussed next.

3.3 The Political Approach

As can been seen, the system approach is an improvement on earlier frameworks. It does not contradict the teachings of classical framework (the importance of structure, a need to separate planning from performing and recognising the motivating influence of pay) stemming from the work such as Taylor and Fayol. And it incorporated the models disseminated by the Human Relation movement - process improvement that views people as variables that can be manipulated in the same way, as machine will not succeed. These were acceptable description and a starting point for understanding organisations. The improvement comes from recognizing the need to balance all of these with the need to monitor the organization environment, integrate the subsystems, and make decisions, which altogether achieves the organisation's goals. Goals are set at the top, then shared up and passed down to the subsystems such as production, accounts, etc. Each subsystem further repeats the process of dividing up goals down to individual employee; then, provided the right transfers of people, materials and information between the subsystems is carried out and the subsystems monitored and directed to perform as expected the organisation goals will be achieved. The premise here is that management has the right or authority as well as the obligation to impose goals to control the organization and will do so efficiently (Lee and Lawrence 1991). But it should be noted that authority and power are not the same (Pfeffer 1981b) even though they often coexist together. The authority to impose does not necessary translates to ability to impose.

Another problem with the system framework is that it is perhaps too broad and complicated; management is asked to consider the interconnection between every relationship and between everything – something, which is difficult in the real world and certainly something, which the average SME may not be equipped to perform due to aforementioned problems of resource scarcity. In criticizing the system approach, Robert Lee and Peter Lawrence (Lee and Lawrence 1985) noted that practitioners of the system approach rarely state how these responsibilities should be fulfilled, instead they focus on the pursuit of economic efficiency. Should the practitioners have tried to tackle the problem of multiple responsibilities, they would have realized that many of the objectives of the many parties are hard to identify and measure, and that these will vary between organisations. Secondly, they would have encountered the problems of *"incompatibilities between the different objectives, which can only be resolved by conflict, competition and compromise"*. Also, they noted, *"The reality of real world is conflict, stress, ambition, incompetence, nepotism, unreason and fun – all a kaleidoscopic turmoil"*.

It is Niccolo Machiavelli who noted that "there is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success than to take the lead in the introduction of a new order of things". This sentence perhaps best summarises the difficulty associated with introducing change in any organization. Organisations do not stand on their own; people create and run organisations. Change emanates from people who make up the organization trying to get their own way. Hence, any attempt to understand organisations have to start with the organisation's people – the human subsystem of the organisation. Without the ability to influence change, change cannot happen. Influence however is simply power in operation. As Pfeffer Lawrence noted, *"If power is critical in affecting what organisations do, then understanding the stability of power can help us understand the problems and issues associated with changes in those decisions and activities. For those seeking to alter organisations, an understanding of the sources of stability is a necessary first step in the attempt to overcome resistance to change"*(Pfeffer, 1981b).

The point made about power and influence provides another point of departure by this study from the common approach – Political approach. Politics as used in this paper should not be mistaken for skullduggery, underhand practices or tactics, and dysfunctional behaviour. Power as already mentioned is not the same as authority conferred by position in the hierarchy of the organization. Power and politics defined in this way has connotations of ideology and bad ethics. This is perhaps why they are rarely mentioned in literature. It should be noted that power does not reside only with those in authority e.g. managers. As will be demonstrated later even those at the bottom of the organization hierarchy have access to some power. For example, those at the top may have sanction power to sack employees or to withhold promotion but those at the bottom might also have access to special skills or information, which if they choose to withhold can affect output, machine performance, financial position of the company, etc. All of these taken together can restrict the power of management to act with impunity. In this paper the definition of power is adopted from the explanation provided by Jeffrey Pfeffer as well as from Robert Lee and Peter Lawrence:

"Organization politics involves those activities taken within organization to acquire, develop, and use power and other resources to obtain one's preferred outcomes in a situation in which there is uncertainty about choices. If power is a force, a store of potential influence through which events can be affected, politics involves those activities or behaviour through which power is developed and used in organizational settings. Power is a property of the system at rest; politics is the study of power in action" (Pfeffer, 1981b).

"Power is the capacity to affect people, things, situations and decisions" (Lee and Lawrence, 1985).

The natural state of the organisation environment is dynamic equilibrium characterized by state of conflict, political activity, as different organization members naturally pursue ends, which are often to some degrees incompatible. The dynamic balance comes about because most members will seek conflict resolution in order to ensure the survival of the organization in pursuit of their mutual interests. Resolution in favour of a member or a group of members can only be achieved if such member or group has more power. Hence, power is central to understanding the political approach; power decides outcomes. Those who have the greatest power will also be the ones who will gain the higher dividends from the interplay of politics. Examples of sources of power include control and access to information, special skills, money (and other resources on which others depend), power to sanction, control over agenda setting, etc.

The conditions under which the use of power is inevitable was provided by Robert Lee and Peter Lawrence (Pfeffer, 1981b). These include the following:

- Interdependence e.g. what one component of the system does affect the other.
- Heterogeneous goals and beliefs e.g. about decisions and their outcomes as well as goals, which differ.
- Scarcity e.g. if there are slack resources, there will be no need to fight over it. Scarcity makes the conflict worth the effort.
- Conflict e.g. the combination of scarcity, heterogeneity and interdependence create conflict.
- Importance e.g. how significant the decision or resource is will determine whether the conflict will require investment in the use of power and politics.
- Power distribution: when power is highly centralized politicking is almost none existent e.g. there is hardly any political activities under conditions of strict dictatorship. This perhaps explains why some believe that change is easier to implement in SMEs due to predominance of strong charismatic owner managers.

When all these conditions are present, use of power and hence political behaviour cannot be avoided and it is usually the only way to arrive at any decision. Political behaviour pervades the human organizations, as the following narrative will demonstrate:

1. **The author's mentor:** "25 years ago I attended an interview for a job that I thought I have no hope of getting. I went out of curiosity but was pleasantly surprised to be offered the job. It later transpired that I got the job because prior to going to university I was an apprentice welder; the company management has had suspicions about the welders restricting output. They thought that as a former welder I should be able to know all the tricks and help give the management an insider view".

2. **An acquaintance of the author working on a project similar to that of the author who on completion of his 2-year project was offered permanent employment:** "I originally came in to implement 3D CAD system. However I liked the company and decided to do everything I can to secure a permanent job even though management indicated that they might not have the resources to offer me a job at the end of the project. My strategy was to make myself indispensable by going beyond my remit and sorting out all sorts of problems such as quality control, website design, plant layout, IT issues for the company. I taught myself all these skills".
3. **Another friend of the author who worked on a project similar to that of the author but was forced to resign after 6 months:** "Had I known what I know now, I would have probably behaved differently. My project had problem from day one. The original owner of the company retired 4 years ago and sold the company to the Strategy Director and the present MD. The Strategy Director started at the company at the age of 16, twenty years ago and worked his way up the hierarchy from the shopfloor. The MD who is a graduate joined the company 5 years ago as a non-executive director one year before the previous owner retired. The two of them never got on well; the Strategy Director considered himself the rightful successor to the previous owner due to his knowledge of the company. The MD believes that his superior education makes him the right person to manage and naturally have his own vision of the direction the company should be going. The process improvement project was started by the MD; something that the Strategy Director opposed. The manufacturing operatives whose activities I should be improving preferred the status quo and simply ignored me. They wouldn't acknowledge my presence; as soon as I enter the shopfloor they would start banging on their tables with hammer. The Strategy Director knew exactly what was going on but wouldn't intervene. I also complained occasionally to the MD. Believing that the MD should be the most powerful person in the organization and that his support is assured since he started the project, I had the temerity to square up to the Strategy Director and demanded to be supported, who then went to the MD and complained that I have attitude problem. Imagine my surprise when the MD who I thought was my supporter

called me in and berated me for not working well with the Strategy Director and for not having the skills to be a process improvement engineer. I had no choice but to resign. When it came to it, maintaining daily output, and the business relationship with the Strategy Director were more important to the MD than the project and me".

4. **Narrated by Jeffrey Pfeffer (Pfeffer, 1981b):** "The Engineering Electronics company was faced with making a decision concerning into which of two projects - project 1 (sponsored by marketing department) and project 2 (sponsored by engineering department) they should invest the bulk of their extra capital. Both projects have the same payoff but project 2 costs several times more, have far higher risk and require more effort. Using rational investment criteria project 2 would have been rejected in favour of 1 but the company opted for project 2 because it was sponsored by engineering department whose manager was close to the company's president".

The entire frameworks for instituting organization change already described in this paper have nothing to say about events narrated above. Yet, stories similar in nature to these stories can be found in every organization. In the words of Robert Lee and Peter Lawrence (Lee and Lawrence, 1985), "*there can be few managers who could not bring a dozen such cases to mind. They are just commonplace manifestation of a simple fact – in most organizations everybody is not pulling in the same direction. The idea of the firm as a neat 'system' characterized by co-operation and teamwork is not always a true reflection of reality. If we accept that there are both sectional interests within an organization, and see the interactions of interest groups as the key to understanding, and then we have nothing but the political model*". Also, even where there is agreement over goals, disagreements may still exist over means to the ends. It is the political approach that will determine whether the implementer of an improvement program will be accepted, whether the change will be resisted or can be resisted, by whom, by what method, how they might do it, and chance of success.

Awareness of the political nature of the organization environment forces one to become more sensitive to local sensibilities - become more aware of oneself as well as other people. This awareness also equips the person to become more agile and adaptable. The political actor will not react to events, instead he/she will be proactively scanning the environment, and asking some of these questions suggested by Robert Lee and Peter (Lee and Lawrence, 1991) - **“what kind of situation am I in; what are my real goals here; what experience/knowledge do I have to draw on; what alternative do I have; “what impact will different actions have?”** All of these will help the actor to master different behaviour patterns in diverse situations and take steps to affect it in a specific way.

Rational bureaucratic and scientific management models may explain operational steps and tools to use; motivation theories may explain human motivation and how to enrich jobs but all these models cannot explain why management have decided not implement a decision, which evidence incontrovertibly proves will maximize organization goal of economic gains. These models cannot explain why some members of the management and operatives are fiercely opposing the proposed introduction of a new operational tactics or new technology but supported by others. The political approach does – it explains that opposition is likely and should be expected because said change may reduce a certain actor’s power, may make his/her life difficult and that nothing (not even incontrovertible evidence) will motivate the actor to understand and happily accept that which if the opposing actor understands will make him/her look stupid or lose a valued position or income. Hence, based on the understandings gained from this research and review of pertinent literatures the author can now present a conceptual framework depicting process improvement implementation in SMEs.

At the heart of the framework (**shown as figure 3)** is sensitivity to local sensibilities – these could be organisation goals, oftentimes-heterogeneous goals of the various organisation members, the ethos of owner-managers, company culture, norms, etc. Stakeholder analysis, force-field analysis, awareness of the power bases of the various actors and the condition under which they will be used, use of organisational currencies, assertiveness, and so forth will provide the vehicle and means for achieving this. Success is linked via strategic adjustments and a two-way relationship to Deming’s PDSA Cycle. In the spirit of incremental cycle of improvement, completion of one PDSA Cycle becomes the launch pad to start on the next repeat cycle in the direction of the ultimate target of becoming world class. Time will be required (shown on the x-axis) and the next cycle will present higher or incrementing complexity and more effort (shown on the y-axis). But provided that the whole thing rests on the ‘agile’ bedrock of management commitment and use of world class manufacturing tools such as SMED and reduced batch size, success can be expected.

The next section will now present the case study company, the problems it faced and how improvements were introduced.

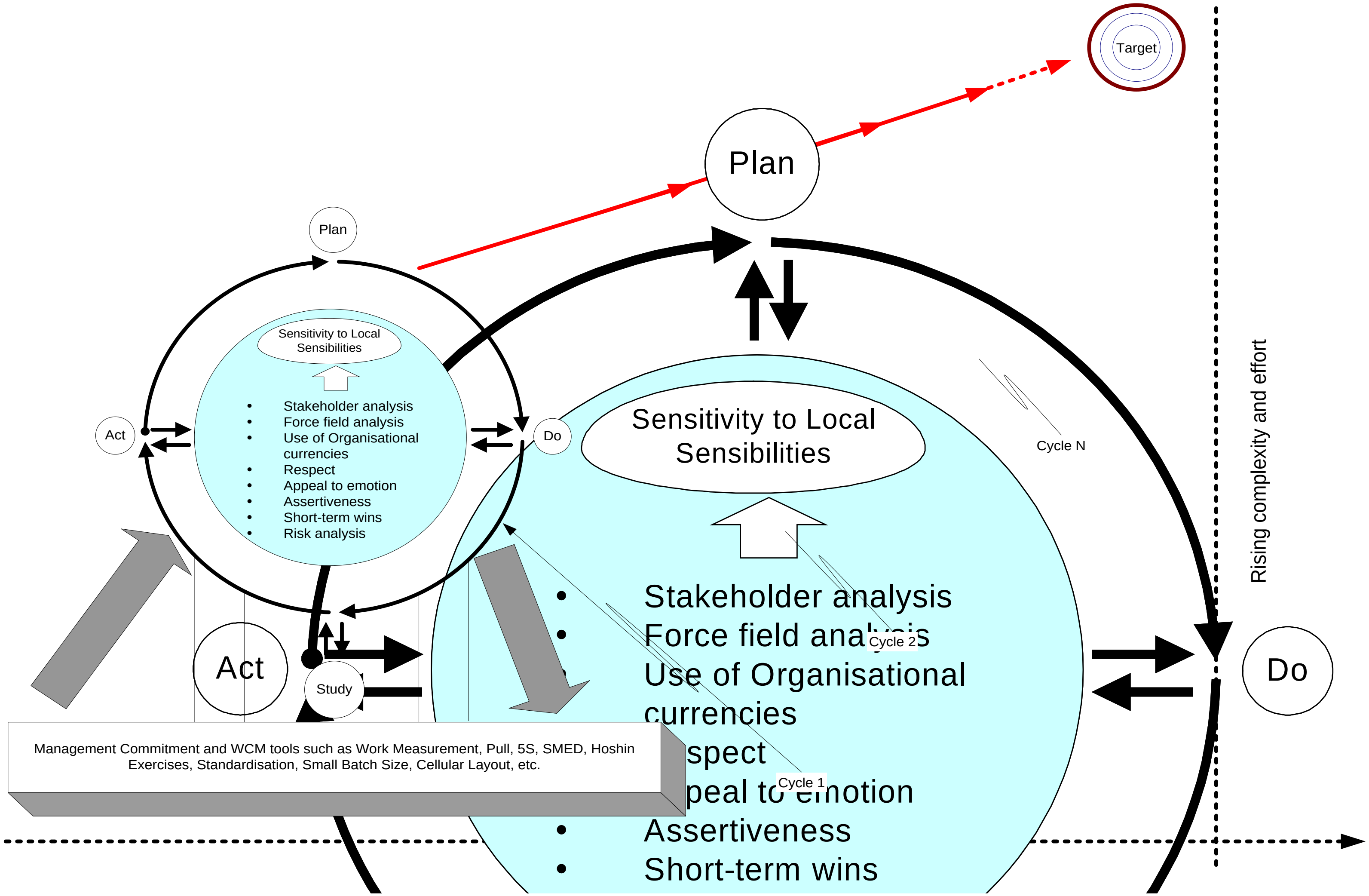


Figure 2: Conceptual framework depicting process improvement implementation in SMEs

3.4 The case study company Background

The case study company, an international company based in Shropshire was established about 30 years ago and produces a range of oil mist, smoke and dust filtration systems. The company brand is one of the best known worldwide, for oil mist filters for machine tools. The company relies heavily on its export markets where just over 50% of its sales revenue is generated.

With at least 75% of the UK market and with its European and North American markets well established the company has focussed attention on developing its presence in emerging markets in S.E. Asia and the Far East to assure its survival and future growth. According to the case study company's MD, these markets hold great potential and there is an increasing interest in improving the workplace environment as Japanese, America and European multinationals open new factories or enter into joint ventures. However, the markets are highly competitive and international competitors have started to enter these markets along with indigenous manufacturers who offer similar lower quality but cheaper products.

3.4.1 The Problems – the business case for the research project

3.4.1.1 Lack of Space, Knowledge Ownership and Change Management Issues

Three and half years ago the company mainly assembled filters, with the components being manufactured on subcontract basis by a local supplier. A decision by this supplier to relocate forced the case study company into purchasing production equipment, employing 8 redundant production operatives from the ex-supplier and hence, becoming a manufacturer.

The new staff and production machines were moved into what was originally earmarked as warehouse space; consequently, space and other resources are restricted. Since the company is not in a position to relocate keeping stock level to a minimum is imperative.

3.4.1.2 Productivity and Profitability

Despite these problems, the business has continued to thrive and expand, particularly in the Far East. The case study company have seen increasing Unit sales to this new market; sales doubled in 2005 and more than 38% of outputs going there since 2006. The company appears to be ahead of most other competitors except for Japanese Showa. However, given the increasing competition, it is evident that defending this position and attaining further growth can only be achieved by being able to provide products faster and at competitive prices.

The company needs to improve productivity and reduce per unit cost not just to remain competitive but also to improve profitability since the market conditions are fixed and there is little or no opportunity to increase selling prices.

3.4.2 The aims

Specific problems are how to get the most out of existing company resources such as utilisation of staff, equipment and space with the ultimate aim being increased shareholder wealth.

Towards this end, known business process improvement techniques such as aspects of Lean Manufacturing, production and operations management were used to review existing manufacturing and production processes, maximise space and other resources utilisation. In summary, the project encompassed the following:

1. Full review of manufacturing, assembly process and, workflow plans for each product line.
2. Increase productivity and reduce lead times.
3. Recommendations for upgrading of capital equipment to improve processes.
4. Develop standard times for in house operations and accurate product costing.
5. Formalise current production process layouts
6. Maximise shop floor space.
7. Formalise drawing process

8. Conduct skill audit of manufacturing staff, which will be used for creating staff development plans.
9. Integrate any process into existing ISO accreditations.
10. Reduce stock levels (the product is made to other and the aim is to reduce stock levels by £80K over 3 years).
11. Carry out cost analysis of all products
12. Reduce manufacturing costs.
13. Improve workflow in manufacturing, and assembly.
14. Initiate culture change by instituting multi-skilling and development of operatives.

Chapter 4

Performing the research project

4.1 Business process examination – laying the foundation and collecting present state information

In this section investigation of the company's current procedures and systems covering sales order processing, and support activities and manufacturing will be introduced.

It is recognised that the manufacturing function alone cannot make a company successful. Consequently, an investigation was started to examine the company's overall business processes. Overall efficiency needs to be addressed in a holistic manner. This called for a need to scrutinize how all the various teams actually interact to deliver the company's goods and services. Gaps and bottlenecks in existing processes need to be identified before improvements can be proposed. Also, it was recognised that the investigation would highlight responsibilities and hand-off deliverables, which in turn would result in clearer understanding of what everyone, need to be doing. The investigation covered procedures, systems and coordination from sales order processing through to final despatch. Consequently, the following were earmarked for investigation:

- Examination of current procedures and systems.
- Documentation.
- Delivery times quoted.
- Manufacturing/Assembly times in relation to delivery times.
- Purchasing procedures.
- Information exchange and liaison between departments.

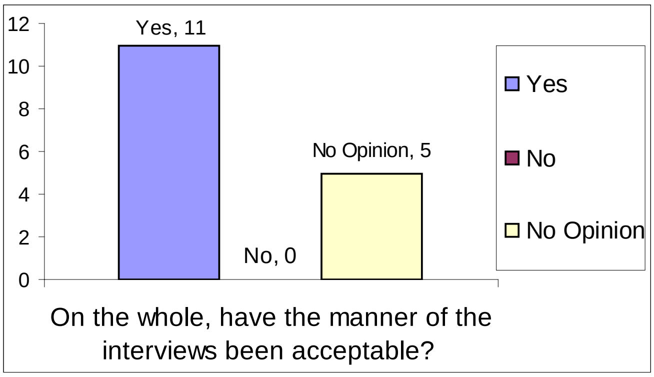
4.2 Method

Qualitative and quantitative information was garnered via a series of semi structured interviews and the aforementioned questionnaire in accordance with 5W + 1H [*]principle, (Segura 1985, James 1997, Tam *et al.* 2001), . These consultations averaged about 30 minutes in length; it began by inquiring about the participants' job and roles in general. Next, further details were sought about current practices. Then a deeper probe was made about expectations and concerns. Examples of questions asked included:

- Where are the major delays or bottlenecks in the current process?
- Does smooth communication exist among the cross functional teams?

The interviews usually ended by soliciting for participants' judgment and suggestions. In addition, a number of works orders were tracked backward to see what was done, who did it, how long it took, and problems faced.

While majority of those polled were happy with the manner of the investigations (Figures 4), they did not however, have very high expectations regarding the outcomes.



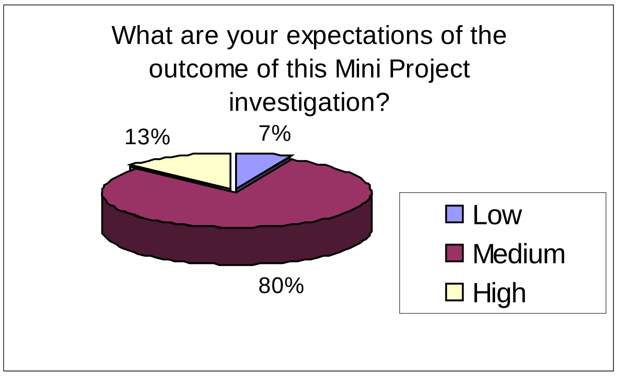


Figure 3: Participants happy with the interviewer but have low expectations

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[*] The 5W stands for 'who', 'what', 'when' 'where' and 'why'; 1H stands for 'how'

4.3 Findings

Findings are presented below, following the order of the interview. Since interviews were given in confidence, none of the results are associated with specific individuals. Quotations were not attributed; instead they were used to add weight to participants' comments. Consequently, even though participants were given opportunities to review what was written about their section, opinions, deductions or inferences expressed here in this study remain the sole responsibility of the author. The processes used by the individual departments were observed, charted and mapped but omitted here due to confidentiality

4.4 Participants

The main participant pool for the investigation mainly comprised from middle management key personnel. However, employees from all departments were polled in order to seek information concerning cross-functional communication and interaction. These employees belong to six departments namely: Export sales, UK sales, Spares/Services, Assembly, Goods-in/Despatch and Manufacturing. They represent four different job types, including managerial, administrative support and tradespersons. The directors were not involved in order to avoid capturing the "as it should be" instead of "as is" information.

4.5 How the company is organised

The company has the following 7 key departments:

1. Manufacturing.
2. Assembly.
3. Goods-in/Dispatch
4. Export Sales - responsible for all unit and spare export sale.
5. UK Sales - deals with sales and installation of units to domestic UK customers.

6. Services and Spares Sales - responsible for acquiring and handling customer service requirements as well as sales of spares to the company's domestic UK customers.
7. Purchasing - manages the company's overall acquisition. It is responsible for ordering stock of every item used in the company except computers and computer consumables. The Department also links the various Sales and Services Departments with Manufacturing, Assembly and Despatch/Goods-in. Details of every processed sales order must be passed to the Purchasing Department. It is also responsible for outsourcing operations that cannot be performed in-house such as powder coating, piercing and plunging, and so forth.

The company has a network of distributors in 35 countries. These are distributors and not agents i.e. they run their own business but are required to hold stocks of case study company's products. Eight years ago the company established a joint venture with a company in India and has recently established another joint venture with a company in Singapore. This is to secure a strong presence in the rapidly growing Asian market. Orders coming from any country must be placed through the distributor for that country only. Bulk purchasing is encouraged as it reduces handling costs. Orders received by the Export Sales Department are treated as either UNIT ORDERS (e.g. complete product), or SPARES ORDERS (e.g. replacement parts and subassemblies). According to statement made by the company, manufacturing and supply capacity is assumed to be 160 units per week but they have usually struggled to supply more than 135 units at the time when this project started. However, they added that the true capacity was about 125 units per week.

The company's Export Sales Department was allowed to accept orders of up to 145 units per week. The UK sales department was allowed 15 units per week. There is no cap for spares and accessories. The usual lead time is 5 weeks as shown in figure 6. However, in case of spare parts that do not have metal, the lead time is reduced to 4 weeks.

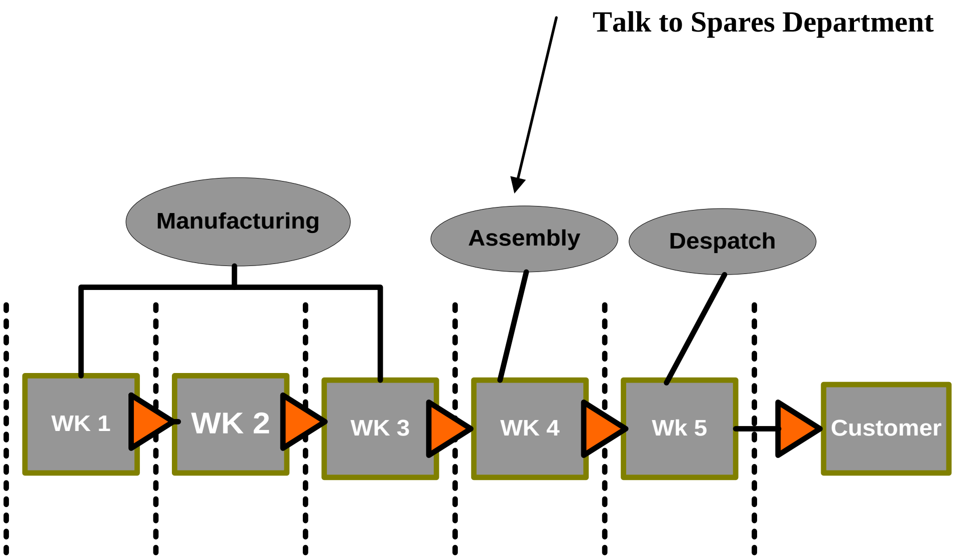


Figure 4: Map showing processing time for completion and delivery of a Unit order.

When an order is received, the sales co-ordinator uses a spreadsheet called UNIT SCHEDULER, which has dedicated columns for each 52 weeks of the year to determine likely despatch date. As soon as the week's unit order adds up to 145, the order processor knows that that week's capacity has been used up hence any new order must be entered in the column for the following week. Next, using the sales order-processing system (SOP), a document number is raised (this number is vital for subsequent tracing of the order). Subsequently, an order acknowledgement is sent to the customer. This will show the customer what will be delivered and when and thus serves the purpose of highlighting any processing error. Furthermore, the company keeps what it calls *Factory Bible* which every concerned department e.g. Assembly Department can refer to. The *Factory Bible* is a file, which has details of every customer's usual requirements such as voltage, colour, and type of motor.

4.6 Discussion

The report so far has presented an overview of the organisation's structure and its current Order Processing system using techniques consistent with Business Process (BP) analysis methods.

In this section, the established problem domains will be highlighted. Furthermore, summary findings from interviews of selected participants and analysis of the workflow procedure will be presented.

4.6.1 Problems with current system

The overall problems of the current system are listed below as quoted by the participants:

- **Quoted Delivery times**
- **Export sales Concerns**
- **UK Sales Department Concerns**
  - **Services Section Concerns**
  - **Spares Section Concerns**
- **Purchasing Department Concerns**

The following sections explain each particular problem as discussed with the participants.

4.6.1.1 Discussion of the problems with the participants

The participants spoke about their sections and situation, which in most cases were probably biased. They also knew that their comments will be written and eventually made available to the management hence, were probably not entirely open. However, the author believes that since the participants are well integrated and embedded in the company's processes, the results of the investigation are reliable. Summaries of their comments on each particular concern are presented overleaf.

4.6.1.2 Quoted Delivery times

The normal rule is to assemble in week 4 and ship in week 5. However, the author was informed that more often than not this does not happen since expediting and fire fighting is usually the order of the day.

A number of Works Orders were investigated to find out whether the rules for quoting delivery dates are adhered to. No evidence of non-adherence was found. Nevertheless, respondents freely admitted that there are occasions when Late-Orders are accepted as a way of keeping a valued customer happy.

4.6.1.3 Export sales Concerns

In this section the concerns were quoted as follows:

1. Assembly Department does not have enough information to plan ahead. "For example, they have neither control nor access to jobs scheduled next week".
2. Sales Department does not know whether and when a job is going to be late. "We can't tell what stage an order is currently at".
3. "Previously, we used to receive the paper works on Friday before the week in which the job will go out. If not, we are informed accordingly. That doesn't happen anymore, thus having a detrimental effect on our preparedness".
4. "Occasionally the Opera system is bypassed when customers abruptly request a modification of their order even though the order might have progressed down the system".
5. "The system is also bypassed when space is reserved in the Unit Scheduler for orders that are not yet firm. Occasionally the system is subsequently not updated".

4.6.1.4 UK Sales Department Concerns

The concerns were quoted as follows:

1. "We experience a lot of late delivery mainly due to Export Sales orders being given priority over other orders. Manufacturing and Assembly cannot keep up with the demand".

2. "Customers often do not have electric power sources available prior to installation engineer visit, so no power is available to test the Unit[†] thus resulting in delays and waste of engineer's time".
3. "When a works-order is issued, the computer may show Purchasing Department that there are enough stocks of materials in the warehouse when in fact this may not be true; thus causing delays and inconvenience to all concerned". "The main reason for this problem is because stocks of material required for installation are maintained for installation engineers. The installation engineers have a sheet for recording whatever is taken out or returned. Very often, they must take out more materials required for a particular job in order to meet any unforeseen circumstances. However, when not all these materials are subsequently used, the Engineers must complete another form to show that the unused articles have been replaced. This is not always done correctly, for example wrong part number may be entered, and hence an up-to-date stock record cannot always be assured".

4.6.1.5 Services Section Concerns

The Services Section concerns were quoted as follows:

- "It is not always possible to tell when a material ordered for a customer has arrived. The system does not flag up; hence, we must either physically go down to Despatch/Goods-in or the people from Despatch/Goods-in must come up to us. As this is not always possible, delays are inevitable"

4.6.1.6 Spares Section Concerns

The Spare Section concerns were quoted as follows:

- **Late deliveries:** "When ordered goods arrive, we are not always notified immediately. It can take anything from two days up to a week before we got to know that an order has arrived. Hence, we are not always able to meet quoted delivery times.

[†] **The author witnessed a rather long wait at a Redditch based customer**

- **Quality problems:** "Due to time pressures, Despatch/Goods-in does not always perform quality checks properly. We received quite a few complaints from customers for receiving wrong items, incomplete items and improperly packed/damaged items.
- **Stock problem:** When an order for an item is entered into Opera, it automatically downloads the BOM for that item and removes them from the warehouse. However, the item cannot be returned to the system easily, if mistakes were made or if the customer later decided to cancel the order. "For example, a S1 is made up of back-plate, Hub, perforated S1 body and vanes. When an order for a S1 is entered into the system, Opera automatically downloads all these subcomponents and withdraws them from the warehouse. If subsequently the order is cancelled or amended, Opera won't let you physically put those stock back. Purchasing Department must go into Opera and physically re-enter each and every subcomponent that makes up the S1 back into the system. This leaves room for errors and can be a source of headache/niggles.

4.6.1.7 Purchasing Department Concerns

The Purchasing Department were concerned that:

- Sales do not always update Purchasing with information about part-completed/incompletely fulfilled orders or partial despatch orders. Their practice is to simply delete the outstanding jobs and process a new Works Order. In the meantime Purchasing wrongly assumes that the old Works Order is still in progress. Thus causing waste of time and resources for all concerned. This can also cause double ordering of stock.

- Spares for export – "Works Orders are raised too far in advance for example, we are now in December but orders for February and March have already been presented to me. This causes me problems with stock, as a lot of the spares are **kitted parts**, which the computer system automatically takes out of the stock as soon as the Works Order is raised. The computer system does not tell when orders are due to go out. Consequently, I might wrongly assume that we do not have enough stock when in fact we could have a whole shelf full. Raising an order no more than a month prior to despatch would help".

4.6.2 Participants' judgment and suggestions

Apart from above complaints, the interviewees also provided highly constructive advices on how to improve the value adding activities of the company. So, not only did they highlight crucial problems, being process-owners, they also came up with solutions. These are presented below according to which department they originated from:

4.6.2.1 Export Sales

1. Distributors should be encouraged to hold minimum stock.

2. We need a system that warns Distributors that their stock is running low. This should help us to level demand and bring stability.

4.6.2.2 UK Sales

1. "Communication across departments must improve".

2. "A means of keeping track record of what is or not in stock must be found".

4.6.2.3 UK Services and Spares Sales

1. "Communication across departments must improve".

2. "Inventory management should be re-examined and reorganized".

4.6.2.4 Purchasing

1. Sales co-ordinators should discontinue the practice of deleting partially fulfilled orders and restarting the process. They should simply invoice what has been completed, highlight outstanding items in the Works Order and communicate status quo to Purchasing. "Better still, Opera should be configured to stop Sales co-ordinators from tampering with Works orders that have already progressed down to Purchasing. Even better is a system that flags up Purchasing whenever such amendments occur".

2. Goods-in and Despatch needs an extra permanent worker (trained) who is dedicated and responsible for receiving, checking, stocking, booking and spotting when stocks are low (an inventory specialist)."That way delays and quality problems being experienced in that section can be avoided".

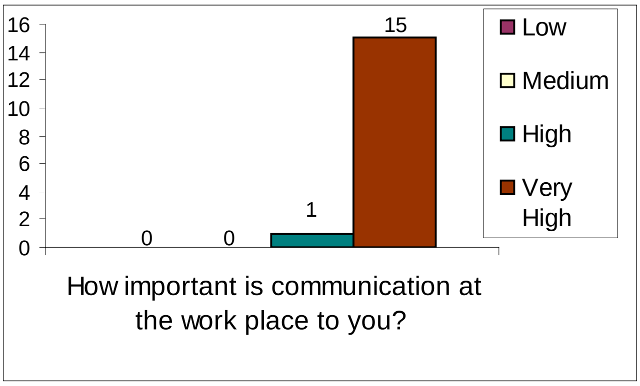
3. Media, Spares and Services people can use Opera to check stock. "They don't need to wait for Goods-in to tell them about availability and arrival of goods".

4.6.3 The author's judgment and Suggestions

4.6.3.1 Information exchange and liaison between departments

Good communication results in smooth running of every system because it helps to eliminate surprises that so often lead to poor planning, delays, non-delivery and poor quality. Each department must see themselves as buyers and sellers of information. Substandard information will ultimately erode profitability. Hence, the company needed to institute regular cross-functional team meetings and interactions as it is clear that information exchange and liaison between departments was poor.

Results from the interviews and the opinion poll/questions developed by the Author (*see* appendix D) proved that cross-functional communication is very important (figure 6) to the case study company's employees.



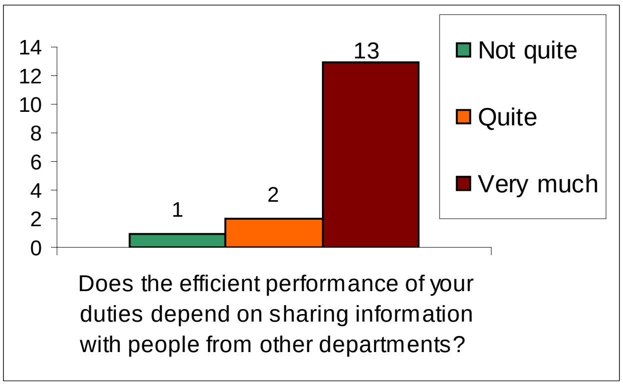
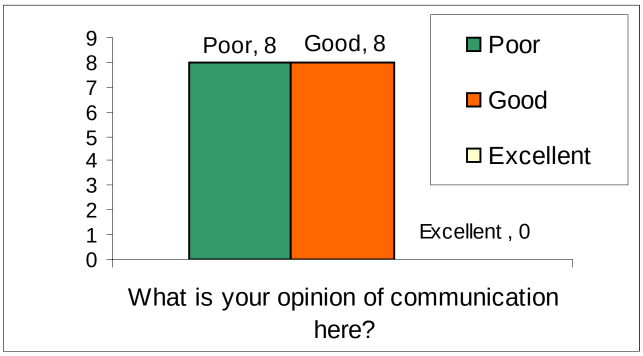


Figure 5: Communication and sharing it is very important

Opinions are divided when asked to rate communication at the company (figures 7). They did not think that communication at the company is excellent. More than half of the people polled think that they have been let down by poor cross-functional communication recently.



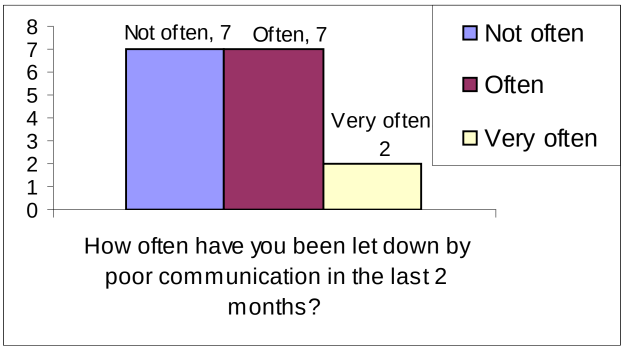


Figure 6: Response to survey on cross-functional communication

Only two people responded when asked to give an instance when they have been disappointed by poor communication (figure 8). One respondent gave an example of an incident when goods that should have been delivered directly to a customer were instead brought to the company's premises thus resulting in avoidable "heavy and costly freight". The other respondent mentioned a time when goods were not despatched on time.

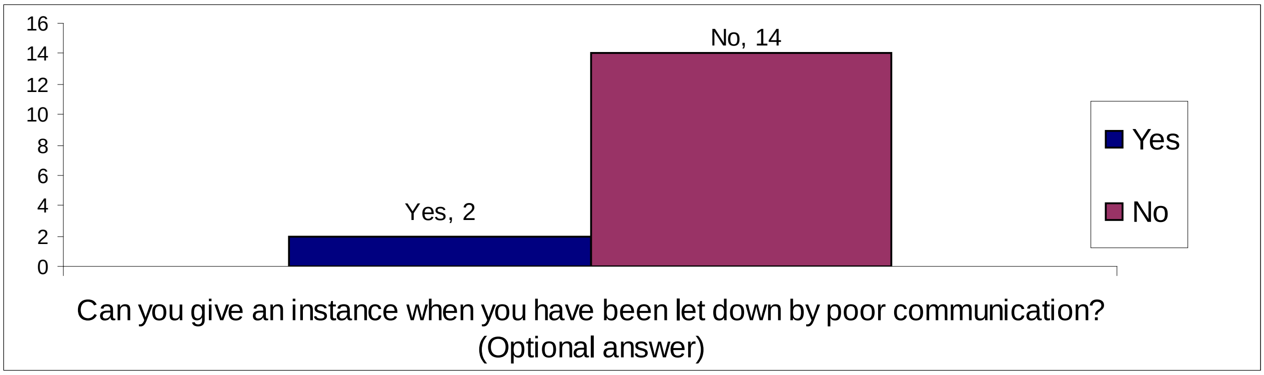
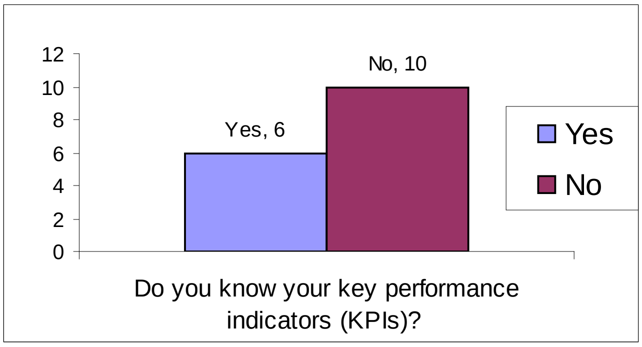


Figure 7: Respondents are afraid of talking

The remaining 14 respondents were very reluctant to mention a specific incident thus reinforcing the author's belief that communication is not as open as it should be.

4.6.3.2 Procedures and Documentation

Majority of those polled said that they have a job description but no written standard job procedure detailing how they should perform their jobs (figures 9). 6 out 16 respondents did not know the baseline against which to measure how well they are doing their jobs. Apart from the method statement written for the service technicians, the author saw the author saw no other written job procedure. Export sales have one but it is out of date.



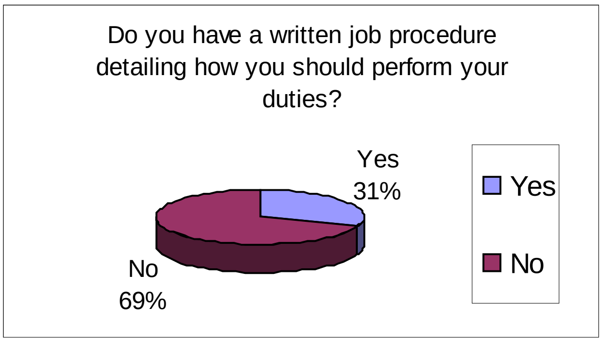


Figure 8: Majority do not have written procedure and do not know key performance indicators (KPI)

The company needs to create a well written, non-technical standard job procedure detailing steps and sequences required to carry out the various job functions. It will be useful to utilize the knowledge and inputs of the various user departments.

Current procedure is of informal nature relying heavily on memory and familiarity; it is also paper work driven. The current procedures work but as can be seen, they lack consistency, clarity and predictable interface. With a standard procedure and mapped workflow, the hand-offs and KPIs are easily visible. Hence, the things that constitute Critical Success Factors (CFS) for the company can be measured and determined. Such metrics may include things such as percentage of customer (internal and external) complaints, proportion of orders handled on time, and so forth.

4.6.3.3 Purchasing

How the depart handles non-standard orders is wasteful. Usually, each of the case study company's unit is painted either grey or black. If a customer required none of these two colours i.e. a non-standard colour this would be noted in the Works Order. When it is time to assemble such order, Purchasing Department issues a Paint Order to Assembly. The required number of Cases are then pulled out from an already powder-coated batch and sent back for re-spraying. In such circumstances, they are not re-powder-coated but wet sprayed. This way, Manufacturing does not need to deal with the complexities of separating and powder-coating the usually small quantities of non-standard colours. However, while this may help to reduce complexity, it is wasteful in terms of time, money and other resources. Better planning could have eliminated this waste.

It appears that Purchasing duties are not clearly defined. It needs a clearer demarcation of duties; presently their function cuts across most departments and meander into functions such as scheduling. Sales department should generate orders but should not release them because the computer will de-stock materials for such orders, which may subsequently be forgotten, amended, or cancelled. Ideally, orders should be released and then be passed to a storekeeper. The storekeeper should pick the items and then release the order. A better computer system as described below would also benefit the department.

4.6.3.4 Goods-in/Despatch

Really hard working employees staffed the department; however it is clearly the weakest link in the case study company's value chain. A casual perusal of the company's customer complaint record can easily bear out this opinion.

The department needs a new layout, machinery, and strict standard job procedure. It is also required a trained dedicated storekeeper, who should be responsible for receiving, record keeping, picking of orders, and monitoring stock level. This would make Purchasing and Sales department's jobs easier, since all that would be required is for the Storekeeper to hand the paper works to the appropriate person and time (i.e. after receiving or despatching).

Moreover, the computer system in use for the warehouse management lacks location facility. Hence, Goods-in/Despatch employees rely on familiarity when picking orders. This is not optimal; with materials stuffed into nooks and crannies no one can be expected to remember the location of every item in the stores. Also, new and temporary workers are likely to make many mistakes and waste time looking for things that normally can easily be located in seconds with a few clicks of the computer mouse.

4.6.3.5 The Computer System

The current computer system is either not up to the job or the company is not utilizing its full capability. Hence, in the interim employees should be properly trained in how to use the system properly.

In the long term, the company needs to investigate introducing ERP system. ERP (Enterprise Resource Planning) software systems manage and integrate all data and

processes into a unified system. It perform most activities automatically and restricts everyone into doing things exactly the same way, thus removing the inconsistencies and bypassing of the system. Previously ERP used to be so expensive that only big companies can afford it; happily this is no longer the case. Popular ERP systems on the market include Microsoft ERP, Seiki Systems Job BOSS and SAP.
If introduced to the company, an ERP system will benefit the company by interfacing the following:

Manufacturing: Engineering, Bills of Material, Scheduling, Capacity Planning, Workflow Management, Quality, and so forth.
Supply Chain: Inventory, Order entry, Purchasing, Supplier scheduling, Inspection, Claim processing, and so forth.
Financials: Accounts payable/receivable, Cash Management, General ledger, and so forth.
Customer Relationship: Sales and marketing, Customer contact and services, as well as self-service interfaces for employees, customers, and suppliers. ERP can streamline the activities of even very complex organization. The can also benefit from having such a non-paper driven system.

In summary the following are recommended:

- Create standard job procedures and a swim lane map of all the procedures.
- Look into how to get more out of the company's computer system by expanding the modules and by providing software training for the employees.
- Re-organize inventory management system by providing new layout, machinery, and a computer system with location facility.
- The company needs a storekeeper or warehouse manager.
- Evaluate the introduction of ERP system such as SAP.
- Improve information exchange and liaison between departments by instituting an empowered cross-functional business process improvement team.

4.6.4 Outcomes

Following the investigation, senior management implemented the aforementioned suggestions; an empowered cross-functional middle management team was set up. The team started regular meetings and also produced a report highlighting other problems not unearthed by the investigation as well some urgently required improvements. These include:

Stores management

- Poor labelling
- Delay between goods in and being on the system
- Stock on system not matching what is on the shelf
- Poor tidiness

Reception

- Not enough cover for incoming calls

Cross-training/job cover

- Cover is required for all jobs and clarity is required as to who should cover whom.

Stock levels

- Need for automating purchasing system (auto requisition)
- A question as to whether UK Sales should maintain own store and stock

Export Sales department

- Export orders commandeering manpower (everything stops for containers to go out).

Lines of communication and responsibilities

- Need to know when to go to staff and when to go to line managers
- Need to know who to go to at manufacturing, despatch, accounts or purchasing. Who is the manager in charge?
- Who is responsible for each member of staff in terms of training and teaching role? (Need a formalised management structure).

Management override

- Management were advised stop overriding system when customers go straight to the top.

These suggestions have since been implemented. They recommended a new computer system but also found out that with adequate training the existing Sales Order-Processing system is still capable of handling the company’s information needs. A new manager was recruited to reorganise Goods-in and Despatch. New procedures have been prepared and most of the Sales staff moved together to improve face-to-face communication. As a result, they now report improved communication. In the words of one of the team members, “every problem has not gone away but several good things have resulted as a consequence of the investigation”.

Indeed evidence for improved business process reported by the company include amongst other things:

- Stocks on system now match what is on the shelf.
- Warehouse was reorganised, tidiness and proper labelling prioritised.
- The company have started cross-training; hence, Cover is available for all jobs. Also, due to the new formalised procedure and management structure, clarity now exist as to who should cover whom as well as who is responsible for each member of staff in terms of training and teaching role.

4.7 Conclusion

A lesson that can be drawn from this initial investigation is that improving the manufacturing processes without first ensuring that the supporting business processes is likely to be counterproductive. SMEs should be aware that the process of self-analysis is likely to be painful and difficult. This study has explored how one such initiative can be achieved. Based on this study, it is clear that developing standard procedures understood and accepted by all users is a requirement. An empowered business process improvement team have also been shown as essential towards that effort. This encourages user buy-in, cross-functional communication and externalisation of tacit knowledge.

The results of this section showed that Business Process (BP) tools could play a valuable role for SMEs. For example, it enabled this study to identify problem areas as well as solutions. However, while simple in nature, the invisible reality as made evident by the findings of this section is that the identified problems **are mainly people based**. On the face of it, poor training, lack of formal procedures guiding the activities of the organisation members, and compounded by poor communication, caused the problems. On the other hand, a closer look and reading in-between the line of some of these observations and comments yielded glimpses that can be explained using the political approached because the circumstances as it existed were ambiguous. "*Ambiguous circumstances allow individuals to define a situation to fit their own needs and desires. This redefinition of the situation is often considered political behaviour"* (Kacmar and Ferris 1993).

Conflicts and use of political behaviour often occur due to limited resources and the ensuing competition over these resources. The state of affairs worsens if there were no clear procedures for allocating and sharing the scarce resources. For example, it appears that Purchasing duties are not clearly defined; presently their function cuts across most departments and meander into functions such as scheduling. A major complaint underscored by the study includes how the Export Sales department are given priority over everybody; "everything stops for containers to go out or for large export orders". Recall that power and politics go hand in hand and that resources consist of not only size of departmental budget but perceived power and the ability to commandeer manpower, as Export Sales has been able to do.

When communication is poor or ambiguous, Chinese-whispers, gossips, rumours and clichés will be used to fill its place. In the same way, lack of clear and sufficient information will usually lead to poor performance. Thus, it is evident that creation of a cross-functional team as well as creation of unambiguous policies and procedures to define relationships, handoff deliveries, appropriate behaviours, and line of authority was required. Cross-functional teams create better and open communication and help to decide how a company's shared and scarce resources can be better allocated. The more cross-functional communication the company can generate, the higher the likelihood of reducing any negative impact of politics.

Clearly it is necessary to put the human side of an organisation in order before seeking to improve the technical side. Commencing with the company's overall business process allowed the study to understand and gauge how improvements to the company's subunits will affect the overall system. It also provided the opportunity to gauge local sensibilities and helped to validate the approach used by the study.

Chapter 5

On the Manufacturing Shopfloor

5.1 Assessing the situation

Following the business process examination, attention was widened and directed at how the company manufactures its product as well as how improvements can be made in that area. The commencement of the project on the 3rd of September 2005 coincided with stocktaking day. This enabled the author to observe the full range of products offered by the company, their complexities and a first-hand experience of some of the issues facing the company. Speaking and interacting with the operatives also revealed their misgivings and a taste of the challenge ahead. The operatives made no effort to hide their resentments and the author was told in no uncertain term that "we have been doing this job since decades and if there is anything to improve about the process or the product we would have found it more than twenty years ago. We have seen more than three of your type come and go. You're just wasting your time here".

Thus, it became even clearer that rational bureaucratic models and simply applying the tools of process improvement may not be sufficient to deal with the case study company's problems. It is in this context that the political approach espoused earlier was used to assess the situation.

The cooperation of the group of manufacturing operatives is crucial to the success of the research project hence, strategies with which to influence them towards that end is also crucial. Several studies in the area of group-dynamic have already shown how this can be done (Huczynski and Buchanan 2001a, Lee and Lawrence 1985). The first step is to find out the history of the group by interviewing and talking to socialisation agents such as older members of the organisation, supervisors, cleaners, receptionists, etc. This is not hard because people always like to tell their history. A group's history will usually reveal whether they see themselves as a group; how they became a group; how cohesive they are; whether they have norms; what those group norms are, etc.

Norms and cohesion are important to understanding the behaviour and responses of a group. Norms indicates expected mode of behaviour such as work method and who is accepted as a member, while cohesion explains strength of attachment and positive attitude that group members have for each other. Change imposed by management that infringes a group's norm is likely to be resisted and the chances of that group succeeding will often depend on how cohesive they are.

The author knew a company where operatives were allowed to visit the coffee machine whenever they wished. They could go and while away the time in the toilet with a newspaper when not busy; they called this "disappearing to the library". But on the other hand, they will willingly forego all break times including lunch whenever the company have "rush-jobs". When a new production manager joined this company that I knew of, he quickly put a stop to all these and halted the little liberties. Break times were rigidly monitored as were other control measures. But soon, this company started suffering lower output, machines started developing mysterious breakdowns, lead times got longer and the new manager was out of job within six months.

The strong positive correlation between productivity and cohesion is well documented (*see for example the Hawthorn studies and the Bank wiring experiments*). Cohesion is usually a good thing for a group because of the mutual benefit, such as emotional support that members get as a result. But it can also work against the formal organisation goal; where the goals of the organisation differ from that of an in-group, cohesion will strengthen the group's resolve to resist. For example, if a group's goal to continue earning extra money via overtime is at odds with the organisation's goal to reduce costs by removing overtime work, then measures to increase output within the normal working time will be resisted.

Thus, in order to develop relevant counter strategies, an investigation into the background of the manufacturing operatives was conducted. It emerged that the production operatives have a lot of job knowledge acquired over many years working for the case study company's ex-supplier mentioned earlier. There, they worked predominantly making the case study company's products. Some of them have worked together for a long time (in some case for over 20 years) and have gone through several stages of group formation and became almost tribal mainly due to the adversarial relationship with their former employer. They are loyal to each other, have clear hierarchy, a subconsciously understood ways of doing things and are suspicious of management. Discussions and observations revealed that they are mentally if not physically still working for their former employer.

Due to their (i.e. the operatives') product specific manufacturing engineering knowledge and because the case study company did not have much manufacturing experience, the company had to persuade eight of them to become the case study company's employees when the decision was taken to manufacture in-house. They were engaged to set up and operate the manufacturing shopfloor; they run and maintain the machines, plan production, determine capacity and output, operated break times that differ from the company's other department. In essence, they ran the shopfloor almost like a separate company. Given their former experience, they were determined this time to protect their knowledge and independence. Their cohesion, specialised knowledge, which they have been able to articulate as scarce and hard to replace, and which the case study company depended on to produce its main product gave them very strong bargaining power. Consequently, they interpreted the process improvement effort as a threat and interference by an uppity upstart academic, which must be resisted.

It should be pointed out here that the managing Director of the case study company is a chartered Production Engineer. Nevertheless, the company still lacked the experience of the narrow field of metal spinning and associated processes (hence, one of the reason for choosing to acquire these experience via this study).

The strategic importance of non-substitutable (monopoly) knowledge to organisation political actors is well documented (Pfeffer 1981a, Lee and Lawrence 1985). Such strategies include ensuring that operation procedures are not documented, training new work colleagues verbally, using specialised language, codes and symbols that make the expertise look arcane and difficult to comprehend to the non-initiated, and ensuring that any system or people that can be used to substitute them is not brought into the organisation. The design, technical adequacy, and feasibility of say a new IT system can be attacked.

According to the political model, resistance to change is a natural reaction and part of the process of adaptation. Therefore it is not necessarily unethical and should not be taken personal or judged. The situation should be assessed in order to develop appropriate strategies. The first stage is to determine the nature of the resistance using the following political approach toolkit:

A. What kind of situation is this; is the resistance personal; is this a political situation? For political situation to exist the following need to exist-

- **Interdependence:** Yes, interdependence exists; what the manufacturing shopfloor does affects other components and actors of the company system.
- **Heterogeneous goals and beliefs**: Yes, there are incompatible and divergent goals. On the one side are the management and the Author. The management have goals to improve processes, earn higher shareholder wealth by reducing costs and increase output, wrench control of manufacturing from the operatives. The author has goals to implement the proposed process improvements. On the opposite side are the operatives who have goals of protecting their skills, maintaining their status and independence.
- **Scarcity**: Yes, independence is a scarce resource and one party must loose in order for the other to win; an alternative is win-win negotiation.
- **Conflict**: Conditions of interdependence, divergent goals, and scarcity exist, so conflict is inevitable.
- **Importance**: all actors perceive the issue at stake as very important.
- Power distribution: power is diffused, management have sanction, resource and position power but the operatives have skill and information power; the author have very little power of his own except proximity to power i.e. access to top management.

Since all these conditions are present, use of power and so, political behaviour cannot be avoided.

B. What are the author's real goals? Unambiguous goals are required before political strategies can be formed. The author was very clear about his goals. He is motivated to implement the process improvement and in so doing test the developed framework irrespective of opposition. Hence, a strategy to influence outcome in the desired way is required.

C. What experience/knowledge did the author have to draw on? The author did not have much information about the various political actors (apart from some intimation from the MD about some difficulties to expect). So, principle organisation political actors/groupings will need to be identified and their power sources, power bases, and possible strategy assessed.

D. What are the alternative actions that can be pursued? The author needs to find a range of alternative ways of dealing with resistance to change – push strategy (use of sanctions), pull or motivation strategy, persuasion strategy (give and take, compromise), preparatory strategy, etc.

E. What impact will different actions have? There is a need to determine how the opposing actors will react to the various strategies and to any proposed change.

To answer questions C to E, a number of heuristic tools[‡] are available (Lee and Lawrence 1991, Pfeffer 1981b). Information required to work through these diagnostic devices can be obtained through speaking to as many organisation members as possible and by reflecting on questions such as what financial or emotional interest do these actors have in the results of the issues; motivations; habits; information need and by what method; current opinion about the study; their influence

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[‡] It is not possible to display the true Actor/Issue matrix, Relationship matrix, Ends/Means matrix, Stakeholder Analysis and Force Field Analysis used due to confidentiality issues and due to their highly personal and subjective nature.

and who influences their opinion; how to manage their opposition if they are not supportive, and so forth.

Actor/Issue matrix was used to ascertain who is likely to be for, against, neutral as well as what power influence each actor has with respect to each key issue required to attain the goals. **Relationship matrix** was used to identify relationships between the actors – power networks, coalition and allies, rivals, etc. **Ends/Means matrix** was used to assess goals and prospective strategies various actors are likely to use and formulate appropriate strategy. Obtained results and inferences were next used to assemble stakeholder analysis and force field analysis. Figure 10 shows a sample Actor/Issue matrix, Relationship matrix, and Ends/Means matrix.

		Possible political actors		
		A	B	C
Key issue	Work measurement	For	Against	Neutral
	Plant layout	For	Against	For
	SMEAD	Not sure	Against	Neutral
	Knowledge transfer	Strongly for	Against	For
	Batch size reduction	Not sure	Against	Against

Actor/Issue matrix

Actors	A	B	C
A	X		
B		X	
C			X

Relationship matrix

Actors	Poss. goals	Means to goals
A	•Control •Profit	•Sanction •Resource control •Authority
B		
C	•Control •Influence	•Scarce skills •Strong coalition
D		
E	•Job Security	Neutral

Ends/means matrix

Figure 9: Sample heuristic political diagnostic devices - actor/issue matrix, relationship matrix, and ends/means matrix

The purpose of Stakeholder analysis is to ensure inclusion of all political actors and to maximise their roles and contributions. The importance of participation as a means of influencing positive behaviour and ensuring implementation of appropriate actions is well recognised. To construct a stakeholder analysis, names of the various actors, their interests, potential impacts, and relative priorities of interest are represented on a table as shown in **figure 11**.

In **figure 12** power and interest of stakeholders are prioritised.

Stakeholders	Interests	Potential impacts	Relative priorities of interest
A	Project success, power, and profit	(+ve)	4
B	Power & Job security	(-ve)	3
C	Comp. progress	(+/-) = neutral	0
D	Job security		2
E	Happiness		1

Figure 10: Required actions summarised as Power-Interest-Stakeholder-Prioritisation grid.

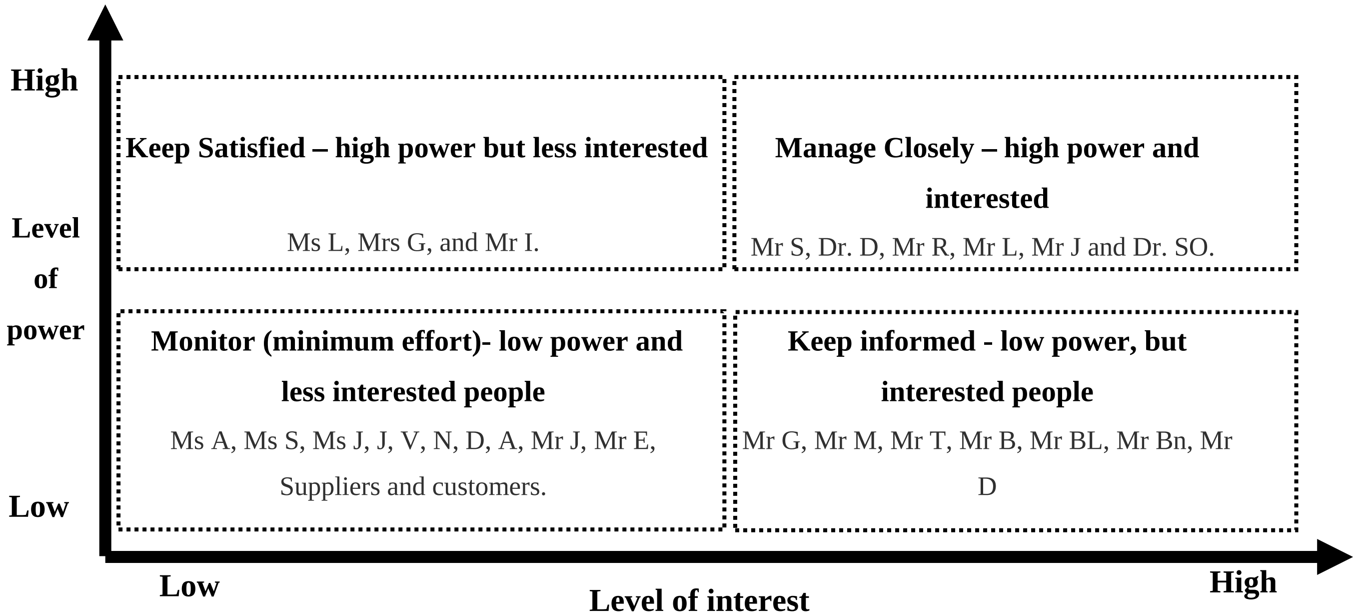


Figure 11: Power Interest Stakeholder Prioritisation

Interpretation: The high power and interested people must be fully engaged and required the greatest effort to satisfy. High power but less interested people need to be satisfied but not bored with too much information. Low power but interested people need to be adequately informed via e.g. talking to ensure there are no major issues arising. Some of these people can be helpful with details and suggestions (e.g. Mr B). Low power but less interested people need to be monitored but not bored with too much information.

In **figure 13** below the grid is extended to underpin deductions about the stakeholders, for example who is likely to be supporter (green), blockers/critics (red) or neutrals (orange).

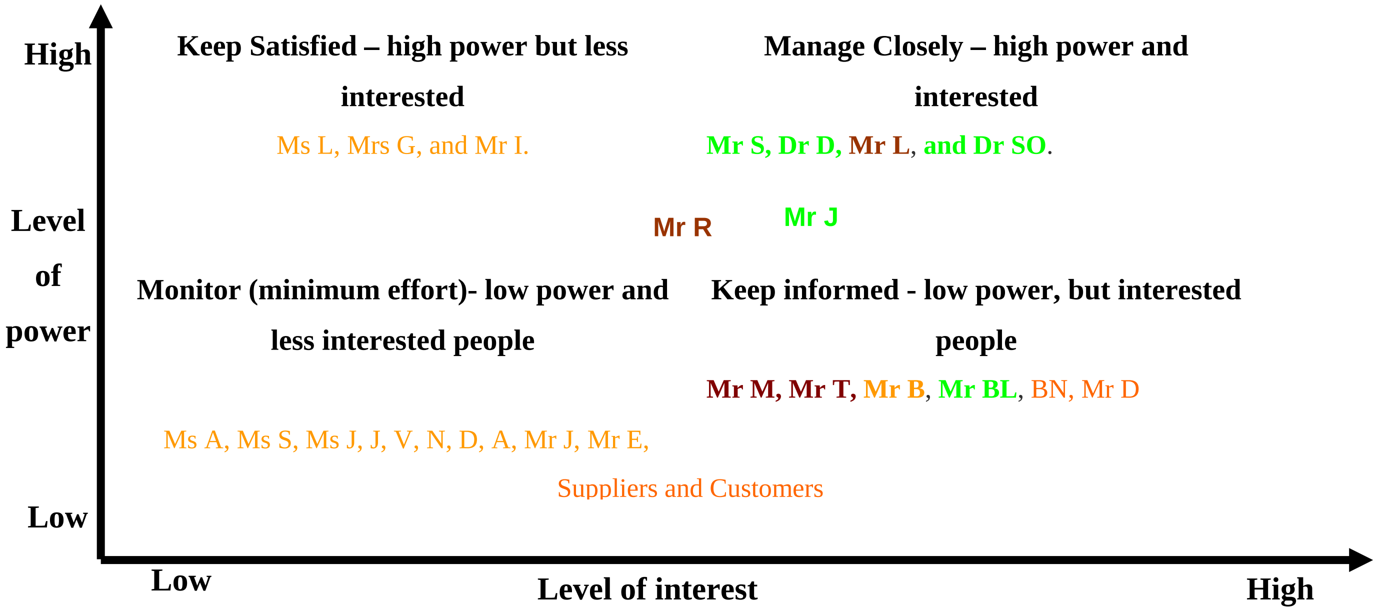


Figure 12: Power Interest Stakeholder Prioritisation with stakeholders marked

Interpretation: More effort will be required in persuading Mr L and Mr R of the benefit of the study; both are very powerful and should never be upset. Mr R is a critic but unsure whether to be interested or not; Mr L is a blocker and very interested. Mr S, Dr D and Dr SO need to be managed since they are powerful supporters; alliance with Mr J and Mr is possible and can be useful since they are both influential and supportive respectively. Mr B, BN and D are neutral; with more effort and attention may be persuaded to become more supportive.

The analysis was also used to plan how much time to devote to each of the stakeholders, what message to convey, and method of communication. For example the staff employees, Mr R and S are happy with formal meetings and written communication while the shopfloor workers are not. Hence, informal chats early in the morning or during lunch while discussing sports and making jokes was more suitable. An abridged stakeholder analysis table with communication plan is shown below as figure 14.

Actors	Communication approach	Key interest & issues	Current status	Desired support	Desired project role (if any)	Actions Desired (if any)	Message Needed	Actions and & communication
	Formal & informal	Productivity	Advocate	High	Mentor		Progress report	Regular formal meetings
	Formal	Project success	Supporter	High			Progress report	Regular formal meetings
	Informal	No conflict	Neutral	Medium				
	Informal	No conflict	Neutral	Medium				Informal
	Formal & informal	Mentor & project success	Advocate	High	Mentor		Progress report	Regular formal meetings
	Formal & informal	Comp. progress	Neutral & doubter	High	Mentor		Progress report	Regular formal meetings
	Mainly informal	Power & Job security	Blocker	High	Supporter		Assurance	Regular meetings

Figure 13: Stakeholder communication worksheet

Hand in hand with the Stakeholder Analysis a Force Field Analysis was also developed. Force Field Analysis was contributed by the social psychologist Kurt Lewin; it is based on the idea that an issue is usually held in dynamic balance by the interaction of two opposing forces namely those supporting (driving forces) and those opposing (restraining forces). Hence, for change to occur driving forces must exceed restraining forces. An abridged version of Force Field Analysis developed to evaluate the powers of the various actors, weigh up and highlight power balance is shown as figure 15.

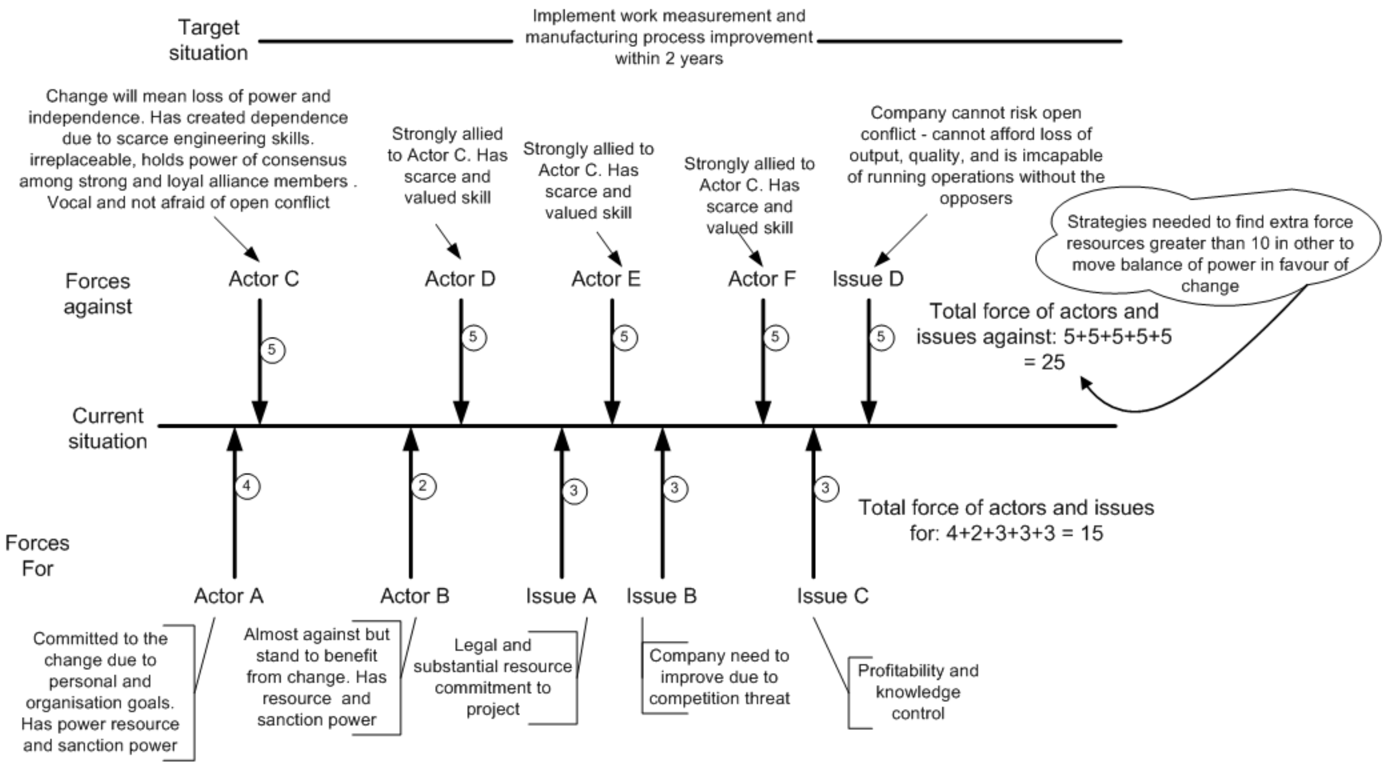


Figure 14: Abridged Force field analysis

As can be seen, forces against change are greater than those in favour. Hence, the action research project may fail unless effort is made to increase the forces in support of the proposed changes. Effective tactics that can be used to ameliorate resistance include (Osland *et al.* 2001) , (Pfeffer 1981b):

1. Coercion – use of or threat of force.
2. Use of ability to deliver rewards and punishments
3. Use of power position of role and normative power based on values and right to manage
4. Manipulation
5. Co-optation
6. Education and communication
7. Negotiation
8. Use of interpersonal skills to build trust, shared goals, or win-win.
9. Expert power that comes from superior knowledge, skills & abilities.

Tactics 1 to 6 were not available to the author and would not have been used were they available. Power is best used when used subtly and unobtrusively. The most useful power available to the author throughout was management support and expert power. The author has expert knowledge of the processes and used them to reduce the myth of scarcity (i.e. of their knowledge) and condition of dependence they created. The stakeholder mentioned above was used to develop alliances. Consultation and negotiation as well as appeal to emotion were used. Areas of agreement were isolated and goal congruency sought.

5.1.1 Conclusion

Change is likely to create conflicts and resorting to motivation theories or rational bureaucratic models will not provide sufficient insight. Becoming angry and judgemental will neither remove the resistance nor explain it. Power and politics are integral part of most organisations; therefore the political approach cannot only compliment motivation theories and rational bureaucratic models but can often yield the greater dividends. The next section will introduce main work implemented on the manufacturing shopfloor with the aid of above strategies.

5.2 Knowledge capturing and learning to see work flow on the manufacturing shopfloor

In order to improve production activities, the first step is always to know the source of the problems. This call for definition of what the standard is i.e. what the present state is (as is) and the desired standard (future state). The case study company does not have major manufacturing quality issues; hence the project concentrated mainly on improvements that reduce costs, lead-time as well as increasing workspace maximisation.

In pursuing above objectives, several concepts were borrowed from the Lean manufacturing methodology. Lean provides great process improvement tools but it also has its difficulties. It was not possible to implement pure Lean due to all sorts of considerations - sensitivity to local sensibilities being one of them. The very effort required to implement it in its entirety is demanding, and if not handled properly can damage the structure of a company. This led Jeffery Liker (Liker 1997) to conclude that “adoption and execution of Lean is a complex, incremental and unpredictable, and the process varies dramatically from case to case”. Thus, a decision was taken to implement a somewhat tempered version of Lean that suits the company’s unique situation.

5.2.1 Methodology

The project followed well-known process improvement steps, these include:

- **Carry out work measurement:**
    - Determine the various process activities and their interrelationships
    - Determine job times since they are vital inputs for planning, working out labour cost, scheduling and budgeting.

- **Identify bottleneck**
    - Increase process capacity by either improving the efficiency of the bottleneck, its availability or moving work away from it.

- **Identify and minimise non-value added activities** (e.g. production of excessive in-process inventory)
    - Use SMED (Single Minute Exchange of Die) technique, 5S, Hoshin exercise (working on the shopfloor to find improvements), etc.

- **Use analysis to make improvement decisions such as:**
    - Investigate product redesign for better manufacturability.
    - Differentiate between process and operation, look into process as well as layout (e.g. U cell) redesign.
    - Look into outsourcing.

- **Look into behavioural side of process improvement:**

  - Use influencing skills to promote a culture that supports the direction the company is taking.
- **And so forth.**

Data as in the earlier investigation were collected via interviews, and participative observation. A record of daily involvement in both formal and informal meetings with the production operatives was also kept. Various elements of a process were first defined to aid clarity; these include process scope e.g. where the process starts and where it ends, process inputs (e.g. what are converted by the process), process outputs (e.g. the filter products that are produced), process controls (e.g. procedure) and process resources (e.g. skills required in order to convert inputs into outputs).

5.2.2 Workflow Study

The company's production operatives have high level of informal job knowledge as they have mostly worked on the case study company's products most of their working life. However, this created a few problems; their job knowledge, which they are unwilling to share have enabled them to attain a strong bargaining position. Furthermore, they are unenthusiastic about trying or adopting new ideas.

Hence at this stage, effort was devoted towards capturing the requisite manufacturing processes/steps as well as formalizing them into standard procedure before seeking any improvements. As noted by (Kumar and Harms 2004) an informal procedure is usually present if for instance an employee is absent, takes a leave or leaves the organization and a replacement cannot immediately step in to carry out the absent employee's duties. This was found to be the case at the case study company. But a progressive and innovative company should not allow the existence of informal system. Knowledge that is not externalized is not useful to any company. This is because, knowledge gives a company its core competency, hence its competitive advantage.

There are nine products in the company's standard product range. In addition, it also offers stainless steel versions of the standard products. The map shown below (**Figure 16**), display an overview of how the company makes its products. Due to the confidentiality, the complete details of the production processes cannot be presented here but a short description would be that the subassemblies start as a bought-in blank from a supplier and undergo various transformation stages. For example, the blank for the Case is first rolled (operation 1) then joined at the Seamer (operation 2) and hammered (operation 3) before being spun (operation 4) at Spinning work station, and so forth.

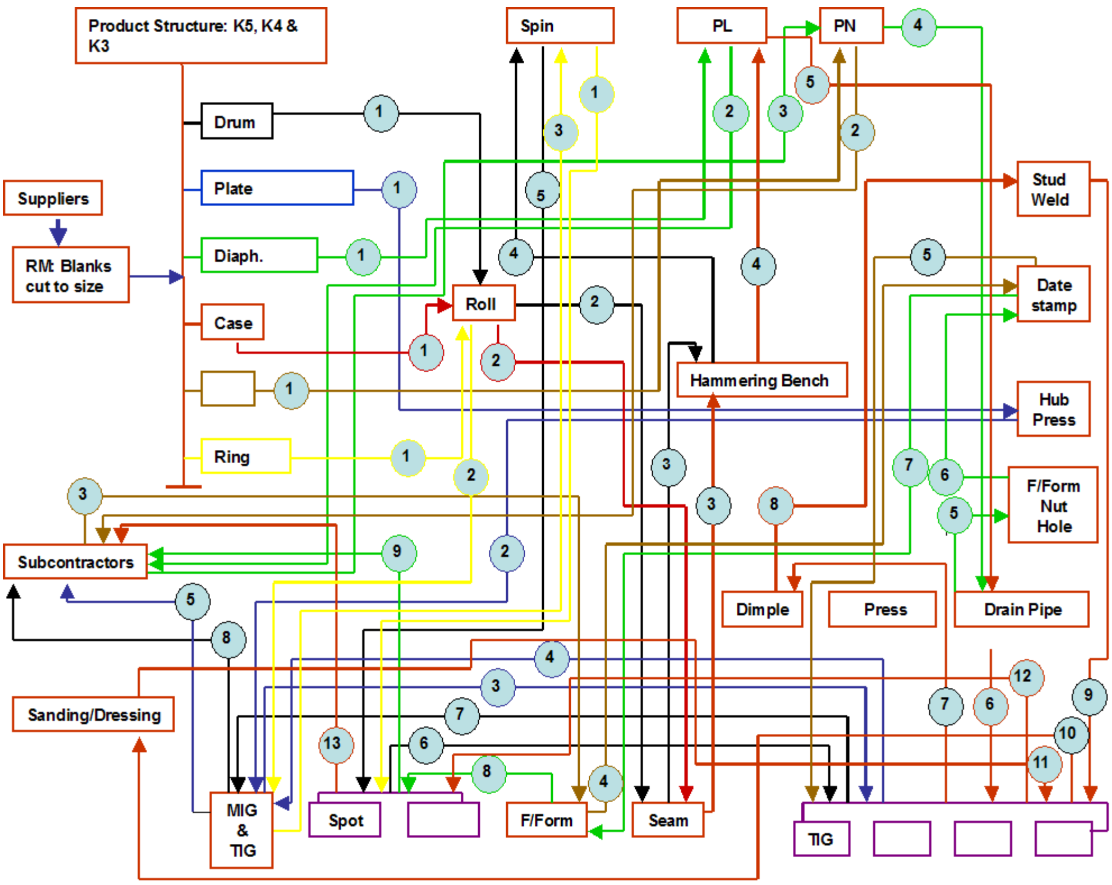


Figure 15: Spaghetti map describing manufacturing steps

Manufacturing steps for all products follow very similar steps. However, the product labelled as K3 have a part called 'Rings' while the rest do not. Also plates for K6, K5, K4, & K3 are bought in components while those of K7, K62, K3 and K2 are spun from blank using the PLB. Next, the various steps were studied in details and mapped as a process chart. The process chart for Oil Ring production is shown (figure 18) as a sample of the captured process charts.

Operation: Oil Ring processing	**Sheet 1 of 1**		**Summary**	
Product:	**Charted by:**		**Operation** ●	
Department:	**Chart Date:**		**Transport** ➡	
Drawing No: ……Part No:	**Approved by:**		**Inspect** ■	
Quantity:	**Approval Date:**		**Delay** D	
Process Chart for Oil Ring production			**Store** ▲	
			Vertical Dist.	
			Horizontal Dist.	
			Time (hrs.)	

	Distance Moved (m)	**Worker Time (hrs.)**	●	➡	■	D	▲	**Description**
1			●	➡	■	D	▲	Pick up blank form RM rack and Roll.
2			●	➡	■	D	▲	Store until needed by MIG + TIG Welder.
3			●	➡	■	D	▲	MIG + TIG Welder collects and transports back to MIG + TIG Bay.
4			●	➡	■	D	▲	Perform MIG + TIG welding operation.
5			●	➡	■	D	▲	Store until needed by Spinner.
6			●	➡	■	D	▲	Spinner collects and transports back to Work Station.
7			●	➡	■	D	▲	Perform Spinning operation.
8			●	➡	■	D	▲	Store until needed by Spot Welder.
9			●	➡	■	D	▲	Spot welder collects and transports back to Spot welding Bay.
10			●	➡	■	D	▲	Spot-weld Oil Ring to Cage (i.e. put cage into Ring and spot weld).
					■	D	▲	Store until required for spot welding to S3

Figure 16: One of the process charts without operation durations

5.2.3 Measuring process performance

The process charts highlighted the need to ascertain operation duration. Also, since reducing lead-time is one of the key aims of the project, operation times were earmarked for measuring. This is to expose performance gaps in the current process and ascertain a baseline for future improvement efforts. Originally, a stopwatch was to be used to time all the manufacturing operations but the operatives resisted it.

As a result, an alternative tool was sought. A job card (Figure 19) was designed and introduced. It was explained that time measurement is not a negative tool for “catching them out” but is required for production planning, and due date determination. Furthermore, importance of time as a tool for accurate costing was impressed on them; accurate costing ensures products are neither overpriced nor under-priced. Good pricing ensures that a company stays in business and provide secure jobs.

Product description		
Part Number if known	Special Instruction (e.g. material, colour – UK, Andy	
Operation Description		**Operation Sequence Number**
Date	**Machine or work station**	**Component (e.g. Lid, Drum)**
Name		
Qty Done	**Time spent**	**Scrap Qty**
Scrap reason		

Figure 17: Job Card used for capturing operation times

After the initial reluctance, the job card was accepted; the operatives started filling and returning it on a daily basis. Information obtained from the job cards were entered in an Excel spread sheet (figure 19).

Date	Product	Component	Operation Description	W/Station	Qty Done	Time spent (Mins)	Time spent	set up Time	Scrap Qty
16/10/2006	3/4000 Case	Case	Roll	Rolling MC	94	70	1.17hrs (70)		
16/10/2006	3/4000 Drum	Drum	Hand Spin	Hand Lathe	54	300	5hrs (300)		
16/10/2006	3002 drum	Drum	Roll	Rolling MC	16	15	0.25hrs (15)		
16/10/2006	3002 drum	Drum	Seam weld and hammer	S.welder & hammering Bench	16	45	0.75hrs (45)		
16/10/2006	5/6000K Drum	Drum	Hand Spin	Hand Lathe	40	240	4hrs (240)		0
16/10/2006	5000 Case	Case	Roll	Rolling MC	10	10	0.17hrs (10)		
16/10/2006	6/7000 drum	Drum	Roll	Rolling MC	50	45	0.75hrs (45)		
16/10/2006	7000 Case	Case	Spin	PLB Spin	60	450	7.50hrs (450)	0.83Hrs (50)	1
16/10/2006	Flange Adaptor	Flange Adaptor	Spin Beads both ends & drill Hole	PNC Spin	100	555	9.25hrs (555)	1.25Hrs (75)	0
16/10/2006	N/G	Hub/Backplate	Hub into Backplate	Fly Press	100	150	2.50hrs (150)		0
16/10/2006	N/G								
17/10/2006	2000 Backplate	Backplate	Spin Backplate (Flow Form)	PLB Spin	200	240	4hrs (240)	0.92hrs (55)	0
17/10/2006	2000 Drums	Vanes/Backplate/Drum	Tack vanes + Backplate to Drum & weld	TIG Welding	25	150	2.25hrs (150)		0
17/10/2006	200mm Flange Adaptor	200mm Flange Adaptor	Spin Beads both ends & drill Hole	PNC	60	310	5.17hrs (310)	0.83hrs (50)	0
17/10/2006	3/400 Drums	Drums	Hand Spin (1st OPP)	Hand Lathe	20	120	2hrs (120)		0
17/10/2006	3000 Drum	Drum/Vanes/Backplate	C02 Vane to Backplate	MIG Welding	49	90	1.50hrs (90)		0
17/10/2006	3-5K Diaphragm	Diaphragm	Bush	?	56	61.62	1.027hrs (61.62)		0

Figure 18: Abridged unorganised operation duration spread sheet

5.2.3.1 Average task duration spread sheet

Initial attempt to organise this information using Excel sort function was unsuccessful. A closer analysis soon revealed the reason – each operative uses a different name or description for the operations, even when the operations are same. It transpired that this is one of the ways some of them tried to use to forestall the project. But even if forestalling were not the intention, since there were no written standard operation steps, it was impossible to group, analyse and use this information.

Thus, the need for standardising the operations became apparent. This also made it apparent that the processes have not been sufficiently understood. It further highlighted the danger of allowing informal system to exist in a manufacturing environment. Consequently, the processes were once more observed and all the tasks as well as subtasks for each product line written down. This was then formalised into standard operation procedures after soliciting the operatives to help amend and validate them. The operations were also given operation numbers; this made it easier to enter into the reorganised spread sheet and helped to reduce erroneous data entry. Six separate worksheets were created, one for each product family (i.e. products that have exactly the same manufacturing steps and share most parts are combined). The spread sheet was set to automatically work out average operation time for each production task as well as average per unit time for each product. A very simplified and abridged version of the spread sheet is shown as **Table 1**. As can be seen in **figure 19 and Table 1**, there are large differences in the duration of operation they initially recorded. This cannot be representative of the real operation duration.

Day	Date	Name	Product	Sub-assembly	Op. Seq.	Op. Desc.	Work station	Qty. Done	Time spent	Per unit time	Setup time	Scrap. Qty	Scrap reason
		Drum											
Mon	16/10/06	Bill	6K	Drum	1	Roll	R. MC	50	45				
Friday	20/10/06	Bill	6K	Drum	1	Roll	R. MC	60	50				
Wed	08/11/06	Bill	6K	Drum	1	Roll	R. MC	30	12				
Wed	22/11/06	Bill	6K	Drum	1	Roll	R. MC	30	20				
								170	**127**	**0.75**			
		Case											
Mon	16/10/06	Brian	7K	Case	3	P. Spin	PLB	60	450		50		
Wed	08/11/06	Brian	7K	Case	3	P. Spin	PLB	52	380		50		
Wed	15/11/06	Brian	7K	Case	3	P. Spin	PLB	41	310		45		
								159	**1140**	**7.2**	**48**		
		Diaphragm											
Wed	04/04/07	Pete	7K	Diaphragm	1	1st Spin	PNC	100	150		40		
Tue	01/05/07	Pete	7k	Diaphragm	1	1st Spin	PNC	267	420		15		
								367	**570**	**1.55**	**48**		

127/170 = 0.75

Average Setup time

Table 1: Abridged version of the task times capturing spread sheet

The data were collected over more than 12 months to ensure that resulting information is unbiased and truly represents stable system characteristic. Next, all the standardised requisite operations and their durations were summarised in a separate worksheet. The spread sheet shows average time for all tasks required to produce the sub-assemblies. For illustration, tables 2 to 4 show average tasks times for K62 and K7 product lines. Table 5[§] summarised the total duration required to manufacture the standard unit.

Operation	Duration
Operation 1	0.73
Operation 2	4.00
Operation 3	5.00
Operation 4.0	2.00
Operation 4.1	2.40
Operation 5	0.43
Operation 6	0.58
Operation 7	1.06
Operation 8.0	2.00
Operation 8.1	1.00
Operation 9	4.00
Operation 10	5.00
Operation 11	2.00
Operation 12	
Operation 13 (True Up)	2.59
Operation 14	0.00
Total Set Up Time	
Total Operation Duration	**32.79**

Table 2: Activity sequence and durations for K62 and K7 S1 production

[§] Some information have been redacted for confidential reasons

Operation	Duration
Operation 1	0.81
Operation 2	4.00
Operation 2.1	1.00
Operation 3 (PLB Spin)	7.68
Operation 4	0.58
Operation 5	0.96
Operation 6	1.20
Operation 7	1.50
Operation 8	3.24
9 Operation	3.00
10. F/Form Hole Drilling (Subcontractor)	
Operation 11	1.00
Operation 12	0.37
Operation 13	9.50
Operation 14 (Tig weld)	7.44
Operation 15	3.00
Operation 16	0.22
Operation 17	1.04
Operation 18	1.90
19. Powder Coat (Subcontractor)	
20. Weld Repair & Special Operations	0.00
Total Set Up Time	
Total Case Duration	**48.22**

Table 3: Activity sequence and durations for K62 and K7 Case production

Operation	**Duration**
Operation 1 (Spin)	1.56
Operation 2. Pierce & Plunge (Subcontractor)	
Operation 3	3.50
Operation 4	0.67
Operation 5	1.40
Operation 6 (Date Stamp)	0.70
Operation 7	1.40
Operation 8	2.50
Operation 9	0.32
Operation 10	1.80
Operation 11(Hand Spin Oil Ring)	2.88
Operation 12	1.00
Operation 13	1.30
Operation 14 (Spot Weld)	1.50
Operation 15	0.67
16. Powder Coat (Subcontractor)	
Operation 17 (Weld Repair & Special Operations)	
Total Set Up Time	
Total Diaphragm Duration	**21.20**

Table 4: Activity sequence and durations for K62 and K7 S3

K62 & K7		K4		K5		K32		K2		K1	
S1	32.79	S1	25.50	S1	26.82	S1	26.63	S1	25.80	S1	26.51
Case	48.22	Case	40.92	Case	41.70	Case	34.61	Case	33.62	Case	33.53
S3	21.20	S3	17.80	S3	17.80	S3	19.26	S3	19.26		
Totals	**102.21**	Totals	**84.22**	Totals	**86.32**	Totals	**80.50**	Totals	**78.68**	Totals	**60.04**

Table 5: Summaries of Subassemblies task times

5.3 Highlighting improvement opportunities and implementing quick process improvement (short term wins)

As evidenced by a number of incidents, acceptance of the job card did not mean end of resistance to the project. Securing buy-ins continued to be problematic. Therefore, it became apparent that something impressive must be done to keep the project alive.

John Kotter in his seminal book, Leading Change, advocates generating short term wins (Kotter and Cohen, 2002). This is because change takes a long time to achieve and short-term wins are required to make people stay the course. Short terms wins boost morale, make efforts seem worthwhile, justifies the costs involved, give credibility to the change agent, and give senior management concrete data and evidence of the viability of their ideas. More importantly, short-term wins undermine cynics and change resisters; this is because visible improvement makes it harder for naysayer to block needed change.

In line with above thinking some short term wins were implemented after meetings and discussions with the manufacturing operatives. The next section will introduce the implemented short-term projects (or mini projects).

5.3.1 Determining true capacity

Since formal operations durations are now available, determining output rate and cycle time became possible. For example, taking 115.74 minutes as the average time to manufacture a unit, [**]and a target weekly output of 160[††] units per week, output rate is 4.1 units per hour or a cycle time of 14.63 minutes per unit. Thus, it can be seen that a target weekly output of 160 units per week is easily achievable using the available 8 work stations.

[**] K7 was used as it is the largest unit and takes the longest time.
[††] 160 units per week was the original weekly target output the study was tasked with achieving.

The company have more than 39 hours available per week; further calculations showed that weekly output of 200 units and above, are attainable with little or no modification to existing production methods and systems. This is important result, which exposed hitherto unknown true manufacturing capacity of the company, and further vindicates the job card introduction.

Next flow diagrams (shown overleaf as figure 20) were next drawn in Excel using the information obtained from the standardised procedure; operation durations from the spread sheet summaries were correspondingly linked to it so that the average duration per task will update automatically. These were then presented to the production supervisor and asked if the times were reasonable and whether reductions or amendments are possible.

Following several meetings, discussions, and negotiations between the Author and the Production Operatives, more reasonable capacity was obtained (between 180 and 200 units per week). (Deming 1986) was right then; process improvement starts with appreciation for system and knowledge about variation. It is clear that the undesirable weekly output of 130 to 139 units is attributable to special cause of variation. When this was removed the system revealed its true capacity. An artificial target of 160 units is a loss to the company; a loss no one would have known. On the other hand a target above the system capacity will not be achieved. Deming said, "*A quota is a fortress against improvement of quality and productivity*". Consequently, it is obvious that further improvement can only be achieved by working on common causes of variation, which is a property of the system. Subsequent sections will highlight further improvement work done to improve the system.

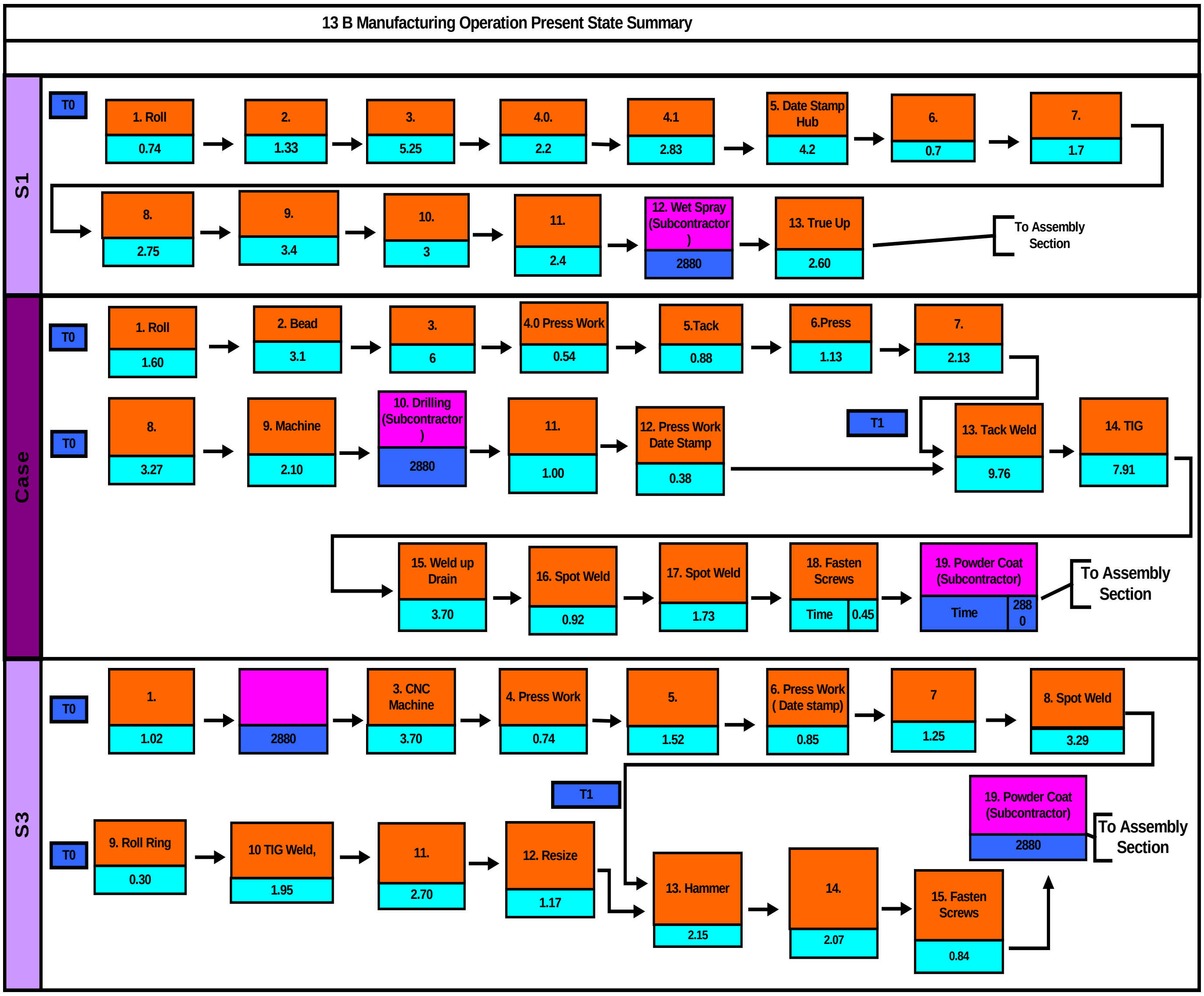


Figure 19: Flow diagram showing summary of operation tasks times for one of the company's product lines (13B).

5.3.2 Bottleneck identification and retrofitting of Hand Lathe

As can be seen from (**figure 20**), Spinning workstation (shown as station number 3 in section S1) is an important bottleneck. Spinning workstation is a bottleneck because the operation performed at it took the longest time and every product requires at least an operation, which must be carried out at the spinning workstation. A study of the operation revealed that retrofitting the machine with a hydraulic ram would reduce operator fatigue and increase productivity. This was achieved at a cost of less than £2000. Picture 1 and picture 2 show the Hand Lathe tailstocks before and after retrofitting. CAD drawing for manufacturing the hydraulic ram is shown as **appendix A**. The Company also purchased a second Hand-Spinning Lathe, which helped to gain further capacity.

Picture 1: Manually operated tailstocks ram

Picture 2: Retrofitted with hydraulic ram

Additionally, it was found that outsourcing production of Ring is cheaper than continuing with in-house manufacturing. Moreover, outsourcing would further free up capacity and encourage workflow. Financial case for outsourcing the two parts are shown below as table 6.

	Material	Cost (£)	Task	OP time (minutes)	Cost (£0.25/Min)	Grand total
	K7 Oil Ring Blank	1.56	Roll Oil Ring	0.33	0.08	
			Weld, Hammer& File	1.97	0.49	
			Hand Spin Oil Ring	2.89		
			Setup (Batch of 100)	10.00		
			Per piece OP time including setup	2.99	0.75	
Sub total		1.56			1.32	
						£2.88
	K3/K4/K5/K6 Oil Ring Blank	1.12	Roll Oil Ring	0.39	0.10	
			Weld, Hammer& File	1.83	0.46	
			Hand Spin Oil Ring	2.17		
			Setup (Batch of 100)	10.00		
			Per piece OP time including setup	2.27	0.57	
Sub total		1.12			1.12	
						£2.24
	K2/K32 Oil Ring Blank	1.05	Roll Oil Ring	0.33	0.08	
			Weld, Hammer& File	1.87	0.47	
			Hand Spin Oil Ring 1st Stage	2.11		
			Hand Spin Oil Ring 2nd Stage	1.63		
			2 Setups (Batch of 100)	10.00		
			Per piece OP time including setup	3.99	1.00	
Sub total		1.05			1.55	
						£2.60
	K2 & K32 Foam ring	0.40	Hand Spin Foam Ring	1.47		
			Setup time (batch of 100)	10.00		
				1.57	0.39	
Sub total		0.40			0.39	
						£0.79

Table 6: Cost of making Oil and Foam Rings in House

Summarily, in-house manufacturing costs the company the following prices per part:

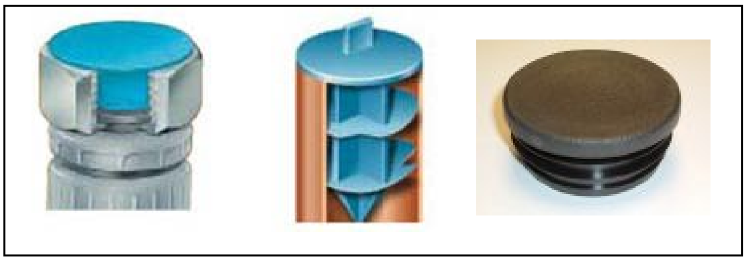
- **K7 and K62 Rings…………………………….£2.88**
- **K3, K4, K5 and K6 Rings……...........£2.24**
- **K2 and K32 Ring…………………………….£2.60**
- **K2 and K32 O Ring…………………………£0.79**

Contrasting against outsourcing shows that savings can be made. For example a bought-in O-Ring K2 and K32 costs the company £1.45; a F-Ring costs £0.40, thus outsourcing gives a savings of £1.15 (i.e. £2.60 - £1.45) and £0.39 (i.e. £0.79 - £0.40) respectively. It is important to note that this calculation would not have been possible without the job timing exercise and the resulting average task duration spreadsheet. This is a further justification for implementing the job card. Another gain of the exercise is the transfer of knowledge from the operatives to the company as well as making tacit knowledge explicit. The company now have a complete breakdown of all the steps required to manufacture its products. This can now form a springboard on which future improvement can be launched.

5.3.3 Improving fastening of Grub-screws to S3s

Aside from K2 and K32, other units require fastening 8 grub-screws to flanged formed nuts on the S3s. The flanged formed nuts are required for installation purposes, however not all 8 nuts are needed and it is not usually known in advance which nuts will be needed during installation. Hence, the nuts must be blocked off by headless grub-screws. The grub-screws also prevent paint from reaching nut threads during powder coating.

The task was normally carried out with Allen keys. Participative observation showed that while the task is not a bottleneck operation, it is nevertheless onerous, particularly when many S3s are required. Several means of improving the operation were brainstormed between the Author and Mr Bill Grantham- one of the more supportive operative. For examples, plastic plugs (picture 3) were considered but were rejected because it would require re-education of customers and may present problems during powder coating.



Picture 3: Plastic plugs

Next, use of power drills were considered but was told that this has been tried and found to be problematic; since the grub-screws are headless, the power drills push them through and out. As a result, use of headed grub-screw (Picture 4) was considered but again rejected because it entails looking for a different flanged formed nut that can accommodate it. Furthermore, costs and availability of such nuts were not known.

Picture 4: Headed grub-screws

Use of Yankee push spiral ratchet screwdriver (picture 5) was put forward; this represented a considerable improvement on previous method but it was also considered too slow.

Picture 5: Yankee push spiral ratchet screwdriver

At the end, attaching a special limiter (figure 21) to a cordless drill was found to be the best option. Funding and permission for the implementation was sought and obtained during a project review meeting. Mr Grantham machined the attachment at home using his lathe. A new cordless drill with chuck was purchased and the method implemented.

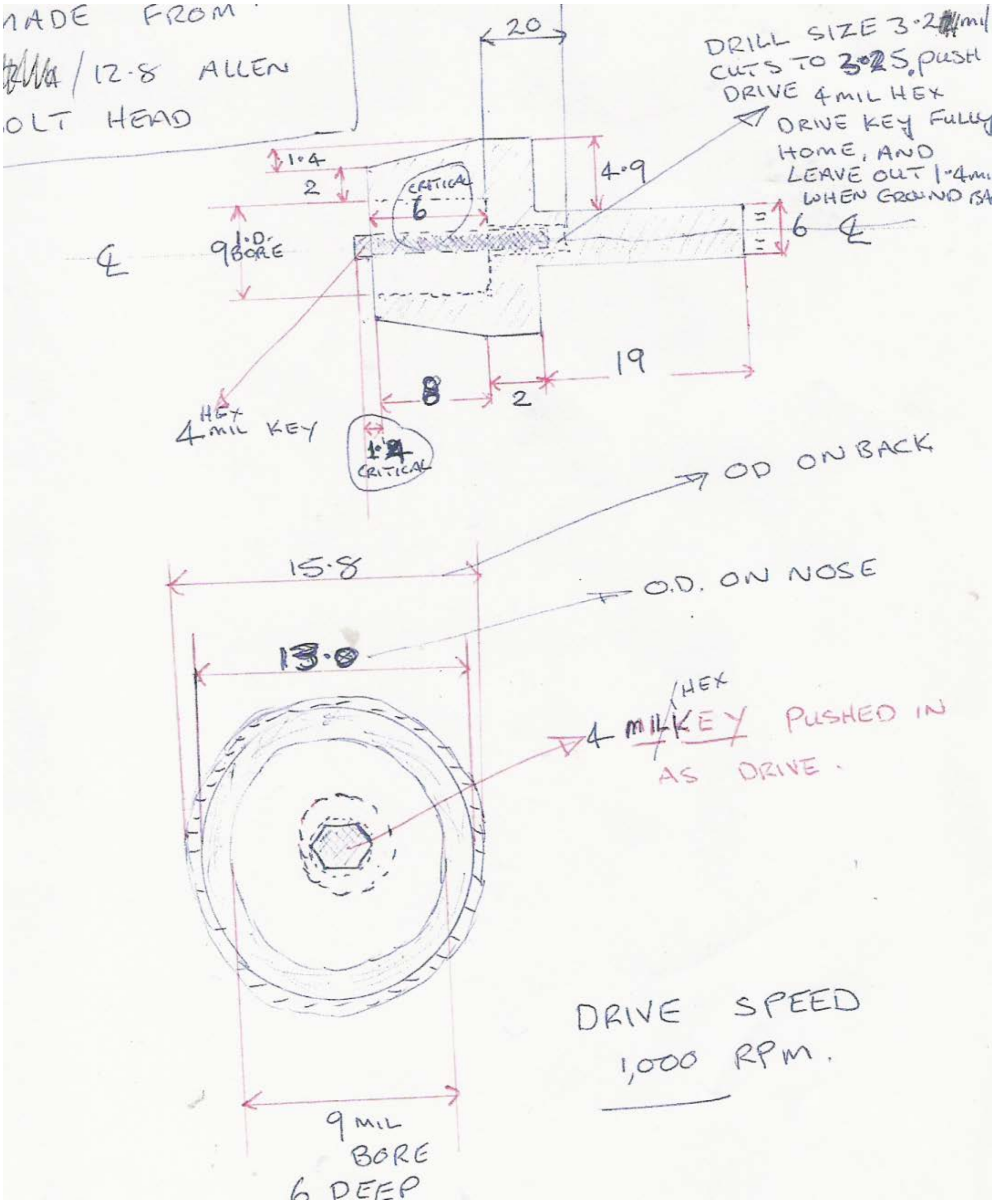


Figure 20: Sketch drawing of the limiter (courtesy of Mr Grantham)

5.3.3.1 Results

The responsible operative reported timesaving of 30 minutes when fastening grub screws to 80 S3s. Previously, the operation took 1.04 minutes per unit; hence the new method achieved a reduction in operation times of:

(80 units x 1.04 minutes) – 30 minute = 53.2 minutes [i.e. (83.2 - 53.2)/83.2 = 36% improvement]

Since 80 units now takes 53.2 minutes then 1 unit will take 53.2/80 = 0.67minutes per unit, which costs 0.67minute per unit x £0.25 per minute = £0.1675 per unit as opposed to the former 1.04 minutes per unit x £0.25 = £0.26 per unit

Hence a per unit savings of £0.26 - £0.1675 = £0.0925 or about 10 pence for every S3 made. Also note that the saved 30 minutes represents extra 44.78 (30/0. 67) S3s or 89.55 S3s per hour as opposed to the previous 57.70 (i.e. 60/1.04).

5.3.4 Multi-skilling of production staff

Even though capacity found to be approximately 200 units per week is achievable, this is dependent on having every required processing skill available. Some key production tasks involved in manufacturing the company’s product entail specialist skills and it will only take an absence due to illness or holiday of one key worker to reduce output and build up unacceptable work in progress. This is a risky situation that makes the company vulnerable. To reduce the risk and ensure smart working, it is imperative to develop a multi-skilled staff. Given this situation, it became necessary to refresh the skill audit of the operatives and use it to highlight training needs and encourage multi-skilling. The audit is displayed below (**table 7**) as a production competency matrix and provides the basis for future operator training plan.

The matrix highlights need to train more people in spinning processes. The company have just one Hand-Spinner, one PLB Spinner, and only one PNC Setter/Programmer. In the interim, the aforementioned risks can be ameliorated through careful planning, for example continuing the practice of not allowing the two Spinners (Operatives 1 and 2) to go on holidays at the same time. It was also recommended that local spinning companies be identified and developed to act as emergency capacity reservoir.

Workstation	Operatives 1	2	3	4	5	6	7	8	9	10
Spinning	A	A[‡]	D	D	D	D	B	D	D	D
True Up / Truing Up	A	A	D	C	C	C	A	B	D	A
Power Spinning	B	A	D	D	D	D	C	D	D	D
PNC	C	A	B	D	D	D	E	D	D	D
Stud. W	A	A	C	A	A	A	A	A	B	B
Slot Fly Press	A	A	A	A	A	A	A	A	A	A
Drain Fly-press	A	A	A	A	A	A	A	A	A	A
F/F Nuts Fly press	A	A	A	A	A	A	A	A	A	A
Hub Fly press	A	A	A	A	A	A	A	A	A	A
Date Stamp Fly press	A	A	A	A	A	A	A	A	A	A
MIG	B	A	D	A	A	A	A	A	A	B
TIG	B	C	D	A	A	A	A	A	A	C
Auto. Seam	B	B	B	B	B	A	A	A	C	A
Power Press	A	A	A	A	A	A	A	A	A	A
Spot. W	A	A	B	A	A	A	A	A	A	A
Rolling	A	A	A	A	A	A	A	A	A	A

Table 7: Production Competency Matrix

[‡] Operative2 is competent at Hand Spinning but only half as good as Operative 1 in terms of speed.

Key: A = Full Competence; B = Competent after training; C = Knowledge and understanding of process but will benefit from further training; D = Training required; E = Not Applicable

5.3.5 Capturing Spot welding procedure

As can be seen from the Competency Matrix, most operative can perform spot welding tasks. However, this is a low skill job, which does not require wasteful use of expensive skilled Welders or Spinners. The job is most suitable for temporary workers or someone from a different department without much training. Standardizing work is an important concept in manufacturing; it is difficult to set up a workstation or reduce setup time if the processing steps are left up to the judgment of individual operatives.

Consequently, Spot Welding operation procedure was captured and presented as an easy to understand process procedure. This is not displayed here at the request of the case study company's Managing Director.

5.4 Small Batch

Subsequent to the capturing of manufacturing process steps, their durations, cycle time and line balancing calculations, implementations of the "quick-wins" as well the ensuing negotiations, output increased. Manufacturing capacity was confirmed as being more than 200 units per week with a possibility to rise up to 250 if required. This is impressive when compared to the former 130-150 units per week (an increase of between 54% and 39%). However, the company have far too many finished and work-in-progress inventories. To reduce these, it became necessary to introduce reduced or small batch method (also called None Stock production NSP or small lot production). This is because stock reduction and space maximisation are major components of the project

In today's manufacturing, it is important to keep inventory down because stock is money tied down; hence it is widely regarded as waste. In traditional manufacturing, large batch size is encouraged because of use of high-capacity none-flexible machines requiring long setup times. Consequently, employing large batch sizes reduces apparent operation times. However, reduction of setup times makes the argument for large batch sizes redundant. **Tables 12** and **13** developed by Shingeo Shingo (Shingo 1988a) show the impact of setup times and the relationship between setup time and batch size. As **table 8** shows, when setup time is high there is a case for increasing batch size but with small setup time there is practically no difference in apparent operation times (**table 9**).

Setup Time	Batch Size	Principle Operation time per item	Apparent operation time
4 hrs.	100	1 minute	1 + (4 x 60)/100 = 3.4 minutes
4 hrs.	1000	1 minute	1 + (4 x 60)/1000 = 1.24 minutes

Table 8: Impact of setup times on principle operation times

Setup Time	Batch Size	Principle Operation time per item	Apparent operation time
3 minute	100	1 minute	1 + 3/100 = 1.03 minutes
3 minute	1000	1 minute	1 + 3/1000 = 1.003 minutes

Table 9: Relationship between setup times and batch size

Small batch size has other uses in JIT manufacturing; it helps companies to overcome the problems of product obsolesce. For examples where product innovation is rapid, small batch sizes will help to avoid scraping of products made obsolescent by the introduction of new variants. The method reduces inventory (hence you obtain space maximisation), shortens lead-time (timeliness), and increases flexibility and customer response. In any case it has been shown that there is a mathematical relationship between work in progress and lead-time; reducing material queues reduces manufacturing customer response time (all things being equal).

The relationship highlighted by the tables is also a warning – never attempt batch size reduction without first reducing setup times. As a result, it was decided to first direct effort towards implementation of Single Minutes Exchange of Die (**SMED**), which is a well-known methodology developed by Shingo while at Toyota for reducing setup times. The next section will describe the steps taken to introduce it at the case study company.

5.4.1 Implementation of SMED and Visual Management

Traditionally, setup will normally start only after the workstation or machine have stopped and ready to start on a new task. However SMED follows a different route, tasks are broken into their individual components in order to increase efficiency by eliminating or reducing those activities that waste time.

There are ample evidences in literature (Mileham *et al.* 1999, Gilmore and Smith 1996a, Shingo 1985, Patel *et al.* 2001) to confirm that a typical setup consists of the following: preparation (e.g. gathering necessary items such as tools and dies), tooling change, setting tools and fixtures, and adjustments. **Figure 23** shows proportion of time typically taken by each component. Gathering necessary items takes about 25% of the time, exchanging parts takes 10%; positioning or setting parts takes 20% while making adjustments will typically take 45% of setup time.

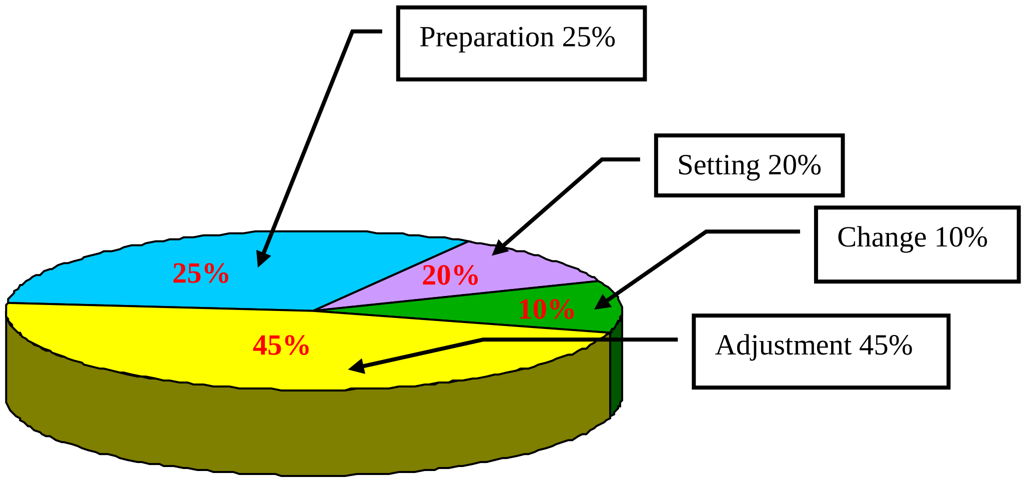


Figure 21: Proportion of time typically taken by each setup component

As can be seen the actual business of changing and setting up take much less time. Hence, the biggest opportunity for improvement can be found in reducing time for gathering items and eliminating the need to make adjustments**.** This provides the motive for distinguishing between internal and external setup. External setups are those activities that do not require the workstation or machine to be stopped while internal setup activities require a stop. So, reducing or eliminating external setups, can improve setup time.

The basic steps for SMED are as follows:

1. Observe current setup process.
2. Differentiate between internal and external setup activities for example by:
    - Developing checklist for needed changeover items.
    - Storing high-use items at the machine.
    - Using die charts and tool boards.
    - Use of visual management: “on deck circle,” scheduling board.
    - Placing tools and parts in order of usage.
    - Etc.

3. Convert internal into external for examples:

    - Standardising operations to minimise internal adjustments

4. Streamline internal operations and eliminate adjustments using for example functional clamps, common nuts and bolts to eliminate Time Lost Removing and Installing Bolts. Replace bolts with functional clamps. Eliminate adjustments using graduated scales, standardised settings, calibrated values, setting gauges/blocks, measurement device, and dead stop locations.

5. Streamline external operations**.**

The process never stops; it requires continuous improvement and participation from everyone. Since, it relies to a large extent on orderliness and standardisation it

normally starts and runs side by side with the 5S principle – Seiri (sort), Seiton (Set – in – order), Seiso (Shine), Seiketsu (Standardise), and Shitsuke (Sustain).
Towards this end, a six-page document showing how 5S would be implemented at the company was prepared. However, following discussions with the management, the idea was dropped because it was deemed too sophisticated for the operatives and current manufacturing environment. A decision was taken to introduce the chief tenets of the methodology indirectly. The Author was advised to work with the consultant for Quality, Health and Safety so manufacturing operatives can see the activities as health and safety measures rather than some new exotic Japanese concept.

Next, in line with SMED framework, the Author first went and had a look (observation); this triggered a number of ideas, which were later developed in conjunction with the shopfloor colleagues. The PLB and PNC machines were identified as those requiring SMED but the concerned machine operators became very hostile. This is understandable since they have been working on the machines for many years and should know more about it than a novice outsider. When it was explained that their knowledge and skill are not being questioned rather, the Author is only trying to assist them using a universal framework that have always worked regardless of machine and industry they were somewhat persuaded and relented.

During the observation, the Author noticed a ventilator with trailing cables positioned against the electric motor that drives the hydraulic system of PLB400. Discussions with the Powered lathe Spinner revealed that it was being used to ventilate the motor since the motor impellor was broken. They have not been able to repair it since the PLB is an old machine bought from Germany. This was obviously an inconvenience and a health and safety problem (tripping hazard). The Spinner had to step over the cables and need to move the ventilator around especially during setups or when moving materials with a Forklift; on one occasion he tripped over it. The discovery was also serendipitous for the Author; it provided another opportunity to do a favour for the operative and thus gain influences or what Cohen and Bradford described as organisational currency (Cohen and Bradford, 1991). Organizational currencies consist of positive sanctions or rewards, which can be used to influence organization stakeholders to comply with a demand. These include resources, information, advancement, recognition, personal support, assistance, co-operation, etc.

Working with the Health and Safety consultant, the impellor was inexpensively and expeditiously repaired. Under the same pretext of health and safety, a handwritten list of all the tools was obtained from the Operations Director. This was then audited and formalised in a spreadsheet. The spread sheet contains information such as machine, make/model, quantity, item/description, serial number/Id number, notes such as condition, and photos. The main purpose of the exercise was to identify frequently needed tools so they can be kept close to where they are needed and to remove unneeded items in accordance with the Sort (Seiri) component of 5S. Sorting is used to eliminate **"just-in-case"** mentality. Unneeded items are eliminated from the work area. However, apart from aiding good housekeeping, the document has other benefits. It is an easily accessible means of tracing the company's expensive investment (tooling).

Following this, a promise was extracted from affected operatives to organise and clean up the tooling rack. Although the tool rack reorganisation was not carried out to fullest potential, considerable progress was made. Next, a SMED setup worksheet was developed and used to record all observed setup activities. An example is shown as **tables 10**. In the same way, all other setup activities were observed and it was found as expected that substantial time can be saved by simply separating external activities from internal, being more organised and staging setup (Mileham *et al.* 1999, Gilmore and Smith 1996a, Shingo 1985, Patel *et al.* 2001) as well as investing on safer material handling equipment. At one occasion while observing the changeover from K2 S3 to FX 4002 lid at the PNC, the operative required a minimum of 3 minutes to go from his station to factory 4 in search of test blank. Fore-preparation would have saved this wasted time. It was found that most times were wasted on:

- Going to fetch tools and equipment such as Forklift, propane cylinder, dies, blanks, clearing the path for the Forklift, etc.
- Waiting for a helper.
- Cleaning tooling.

- Taking off studs and adapter from one tooling and transferring to another.
- Adjustments.
- Loosening and tightening fasteners.

Operator	Machine	Product	Required setup tools	Standard setup time
Brain and Pete	PNC	K2 S3	Setup tool trolley box, Die storage trolley, Programme Tape, Pre-setting gauge.	

№	Task/Operation	Actual Time (Minutes)		Improvement	Target Time		Necessary Activities
		Internal	External		Internal	External	
1	Fetch FLT (Brian)		5	Introduction of a suitable crane will enhance operation and make it a one-man operation thus saving time and manpower.		1	
2	Clear path						
3	Fetch rope						
4	Attach rope to die & secure						
5	Hold (Pete) rope while as Brian lift up die with FLT						
6	Set die down to earth						
7	Remove rope						
8	Roll (Pete) away die to nearby wall						
9	Locate (Pete) new die &roll to PNC						
10	Attach (Pete) rope to new die						
11	Hold up rope while Brian Lifts up with FTL						
12	Brian now drive FTL to PNC						
13	Position Cam-lock (Pete)	2			1.5		
14	Lower new die & attach to PNC						
15	Drive away FLT		1			0	
16	Remove rope						
17	Tighten new die bolts (Pete)	1			0.5		
18	Insert Job programme tape into PNC controls	0.5			0.5		
19	Look for a blank to try out 1st off		3	Get things ready before setup		0	
20	Insert blank	0.5			0.25		
21	Undo handled bolt & adjust back support plate		3	Eliminate most adjustment by using pre-setting gauge. Or calibrate back support.		1	
22	Tweak PNC Controls						
23	Undo bolt handle again & adjust back support plate again						
24	Press necessary buttons & set PNC						
25	Test run						
26							
	Time to produce first good part	16					
		Total New Target Time			6 Minutes		

Table 10: Record of FX to K2 changeover; improvement of 62% is easily achieved.

Another thing that emerged from the observation is disparity between what the operatives originally said were the setup durations and actual observed durations. It was apparent that simply forcing SMED techniques through would not bring required outcome. The operatives, who by the way are vastly experienced engineers needed to be subtly influenced into imbibing SMED concepts so they are able to provide setup improvement ideas on their own. One way this was achieved was showing them results of the observations (tables above); the message being that they can use similar method to achieve a notable reduction in setup times. The implication being that failure to cooperate will necessitate further studying of the setup processes and a lot of pestering until desired result is achieved. Another unspoken message was “make improvement and keep your independence and job ownership or keeping resisting and invite further interference”. As expected, they choose the former.

The informal and formal meetings provided further opportunities for discussing a way forward and for planting ideas. The meetings were used to brainstorm tools and materials, which can help reduce setup. The tools and materials include:

1. Studs
2. DIN 11 to 8 Adaptors and DIN 6 to DIN 8 Adapters.
3. Hydraulic clamping instead of bolts and nuts.
4. Runner Tools.
5. Jib Crane.

The Spinner also advised introduction of a sequence or production scheduling that reduces changeover time i.e. by scheduling according to component family. F**igure 24 and 25** describe how scheduling according to product family can be used to minimise setup; for example, where possible K5 should be followed by K4 and K3, since only minor changes are required. For PLB operation involving K3, K4 and K5 cases, almost no varied setup is required and so, they should be grouped together.

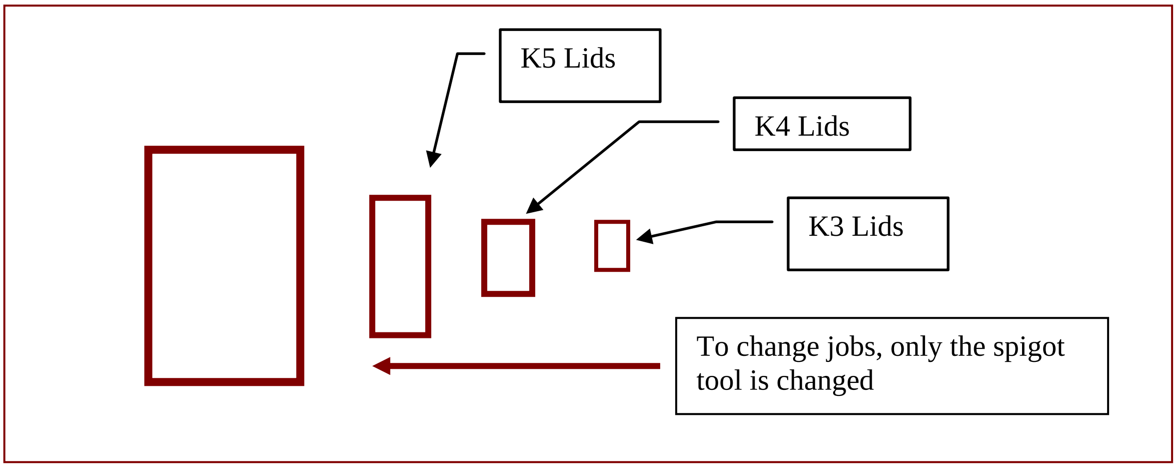


Figure 22: PNC 1st stage spinning of K5/K4 and K3 Tops - only the spigot front, position and front cutter is changed

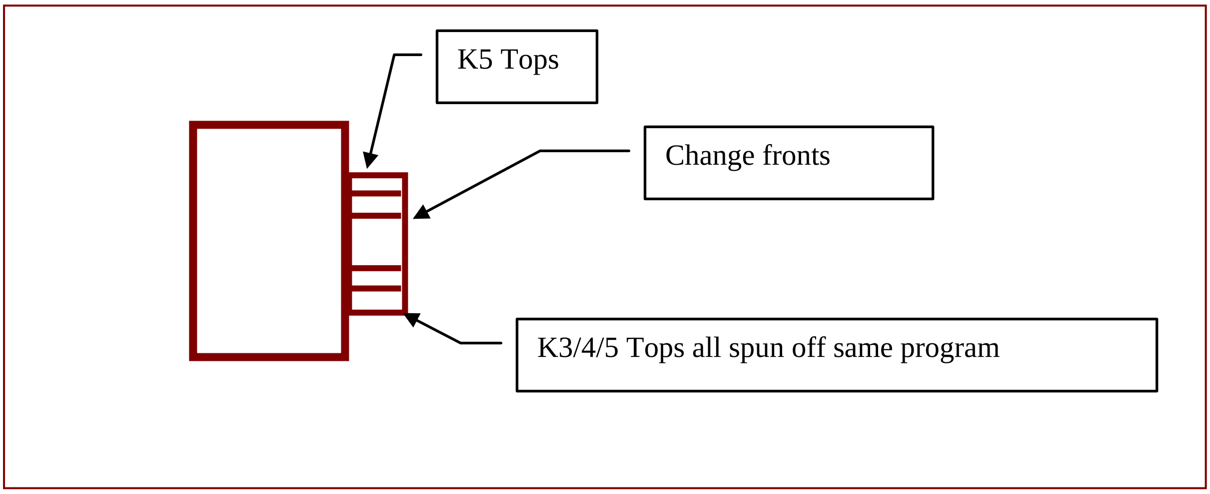
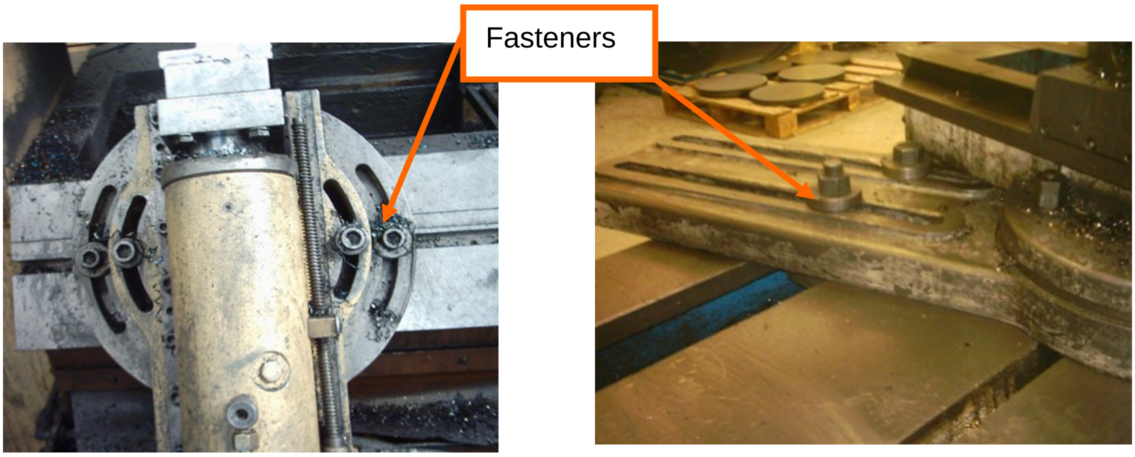


Figure 23: PNC 2nd Stage K3/4/5 Lids all spun off from same program; only runner tool is changed.

A slight setup is required to changeover from K3/K4/K5 to K62/K7. K2, K32, 62, K7 and Series 8 B. Plates has approximately same setup and uses same rollers; all that is required is a change of tooling. K62/K7, K4, K5 and S3s require approximately same setup and rollers. Only the tooling needs changing.

Within four weeks all these measures (the required materials, tools and sequencing) were implemented. As noted earlier, using forklift truck during setup was not only time consuming, it also wasted manpower and was hazardous. So, a case was made for purchasing a crane. Two reconditioned jib cranes were bought and commissioned at a cost of £6500. The cranes proved so successful that the Operations Director asked the author to organise a third crane for hand spinning workstation. However, the proposal to replace some of the time consuming fasteners on PLB and PNC (**pictures 7 and 8**) were investigated and abandoned after cost benefit and qualitative analysis. Also, as can be seen, the machines were already constructed for quick changeover i.e. the fasteners do not need to be completely removed; a quick one turn is enough.



Picture 6: Auxiliary machining unit Fasteners

Picture 7: Fasteners on PLB bed

The measures taken to reduce setup times proved very useful and successful. Setup times went down as demonstrated by the setup time progress report shown overleaf (**table 11**). It shows an impressive drop in setup times of between 25% and 67%, median percentage drop being around the 33% mark.

Job		Duration before	Duration Now	% reduction achieved	Remarks
6002 & 7000 Drum	Hand spin	30	10	67	
	PLB back-plate (1st stage)	20	10	50	
	PLB back-plate (2nd stage)				
	True Up	30	10	67	ought to be down, we have dedicated true-up MC
6002 & 7000 Case	PLB Spin Case Body	50	35	30	Not good enough
	Lid 1st stage PNC spin				
	Lid 2nd stage PNC spin				
6002 & 7000 Diaphragm	1st stage PLB (flow form)	40	15	63	As at 01/05/2007
	2nd stage PNC spin				
	Hand spin Oil Ring	15	10	33	
3000& 4000 Drum	Hand spin Drum	20	15	25	
	True up	30	10	67	
3000 & 4000 Case	PLB spin Case Body	60	25	58	
	Lid 1st stage PNC spin	40			no new result
	Lid 2nd stage PNC spin	30			no new result
3000 & 4000 Diaphragm	1st stage PNC spin	60	20	67	
	2nd stage PNC spin				No data
	Hand spin Oil Ring	15	10	33	
5000 & 6000 Drum	Hand spin Drum	15	15	0	
	True up	15	15	0	
5000 & 6000 Case	PLB spin Case Body	40	30	25	
	Lid 1st stage PNC spin	30			no new result
	Lid 2nd stage PNC spin				No data
5000 & 6000 Diaphragm	1st stage PNC spin	60	25	58	
	2nd stage PNC spin				No Data
	Hand spin Oil Ring	15	10	33	
3002 Drum	Hand spin	30	10	67	Was 30mins @ the highest. Confusing!
	PLB back-plate (1st stage)				No data
	PLB back-plate (2nd stage)				No data
	True Up	15	5	67	5mins was last recorded, could be due to new dedicated true-up MC
3002 Case	PLB spin Case Body	30	15	50	
	Lid 1st stage PNC spin				No data
	Lid 2nd stage PNC spin				No data
2000 Drum	Hand spin	15	10	33	
	PLB back-plate (1st stage)	50	20	60	
	PLB back-plate (2nd stage)				No data available
	True Up	30	10	67	
2000 Case	PLB spin Case Body	20	15	25	
	Lid 1st stage PNC spin	45			No new data available
	Lid 2nd stage PNC spin	75	40	47	No new data available
2000 & 3002 Diaphragm	1st stage PNC spin	60			No new data available but I observed& recorded 15mins & with improvement can be done in
	2nd stage PNC spin				No data available
	Hand spin Oil Ring 1st stage	15	10	33	
	Hand spin Oil Ring 2nd	15	10	33	
	Hand spin Foam Ring	15	10	33	
1000 Drum	1st stage Hand spin	15	10	33	
	2nd stage hand spin	15			No new data available
	True up	10	10	0	
1000 Case	1st stage PLB spin	30	20	33	
	2nd stage PLB spin	15			No new data available
	3rd stage PLB stage	30	20	33	
	4th stage PLB stage	5			No new data available
	5th stage PLB stage	20			No new data available
	6th stage PLB stage	15	15	0	No new data available
	Hand spin Oil Ring	15	10	33	
Average	46	**Mode**	33	**Median**	33

Table 11: Progress report showing 25% - 67% reduction in setup times

5.4.2 Plant layout and material handling

Attention was next directed at formalising the manufacturing plant layout. Frequency of travels between workstations was documented in a tally chart then transferred to ‘travel-between-workstation’ table shown below (**table 12**).

Frequency Movement

Dept.	1	2	3	4	5	6	7	8	9	10	11	12	13	14-17	18	19	20	21	22	23
1. RM Rack	-	16																		
2.Roll		-													16					
3. Spin			-									2		3		11		10		
4. True up				-																
5. PLB					-							3				3			3	
6. PNC						-					4									
7. S. Welder							-						5							
8. Date stamp Press								-	6	3	3						11		6	
9. Hub Press									-										6	
10. F/Form Nut Press										-	4			1						
11. Drain R. Press											-									
12. Drain press												-		5						
13. Dimple Press													-	5						
14.TIG 14 – 17														-			5	7	9	
18. Seamer															-	11				
19. Hammering Bench																-				
20. F/Form Press																	-	5		
21. Spot Welder I																		-	2	
22. MIG & TIG																			-	
23. Sander																				-

Table 12: Travel between Departments

The table highlighted some minor deficiency in the present layout. For example, there is high frequency movement between the Seam Welder and Rolling machine hence they ought to be closer. Hand spinning and Spot welding have high interaction as have Date stamping and the Power press, they ought to be closer. Ideally, PNC just like

MIG/TIG and Spot welding ought to be closer to the main entrance to help with supply of raw materials and flow of material to and from the subcontractors. Changing the layout was not deemed necessary because expected expense and disruption outweighs any expected benefit. Also, the shopfloor is not very big; hence movement lengths between the workstations are indeed very short.

A decision was taken to paint the shopfloor and mark out all workstations as well as WIP and finished goods depots in accordance with visual management demanded by modern manufacturing system. The purpose was to engender discipline, gain space and stop people from storing materials all over the floor space – a place for everything and everything in its own space. Also, around this time, the MD highlighted the incessant problem of fire exit blocking and lack of clearly recognised gangway at the Assembly shopfloor. This created tripping hazard problems for the cleaning staff that usually work during late evenings.

A drawing was produced in Visio as a guide to facilitate the painting and marking (shown as **appendix C**). At first it was not possible to sell the idea to the operatives and it was resisted in many ways. But once again, use of organisation psychology and understanding of organisation politics helped. The Author managed to convince two friendly operatives to take ownership of the task and as soon as they started, others reluctantly and eventually quite joyfully followed. The pictures (**picture 8 and 9**) below show the colleagues during the exercise.

Picture 8: Marking the shopfloor

Picture 9: Marking the shopfloor

Pictures 10 – 13 show the manufacturing shopfloor before and after the plant layout formalisation exercise.

Picture 10: Manufacturing shopfloor before 1 **Picture 11: Manufacturing shopfloor before 2**

Picture 12: Manufacturing shopfloor after painting. **Picture 13: Picture: Neater and organised.**

In addition, material-handling equipment was commissioned. These include back plates trolleys requested by the Operations Director. The trolley was required to minimise knocks and dents to the parts and the consequent negative effect when performing dynamic balancing of the S1s. **Picture 14** overleaf shows a back plate trolley.

Picture 14: Back plate trolley with back plates neatly stored

The Author requested a rack for storing and handling Vanes (Kanban like). **Figure 25** below shows the Vanes' rack frame; it has spaces for 12 stillages; 3 bins for each product line. **Figure 26** illustrates how the system works. Taking K5 as an example, the bins will initially be filled up with 1200 vanes i.e. 400 vanes per bin or enough vanes to make 300 S1s. Then, bin 1 is withdrawn and used for manufacturing until empty. Next, bin 2 is withdrawn and the empty bin 1 sent to subcontractor; this acts as a signal to start producing a new batch of vanes.

When the subcontractor returns bin 1, it goes back to its position in the rack. By this time, bin 2 is empty and as usual will be sent back to the Subcontractor for refilling and so on. Bin 3 serves as safety stock to take care of missed due dates or delays from the subcontractor, unusual large order, emergency, etc. **Pictures 15 and 16** show how the vanes were stored before the measure was implemented.

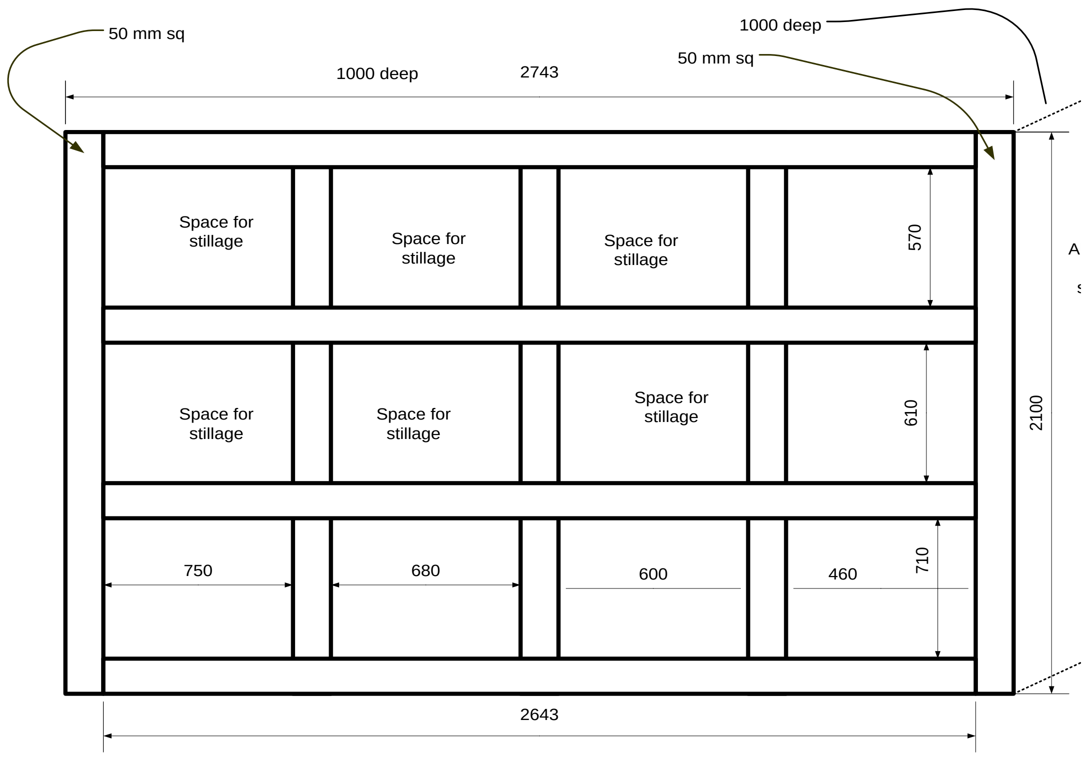


Figure 24: Drawing of Vanes' rack frame

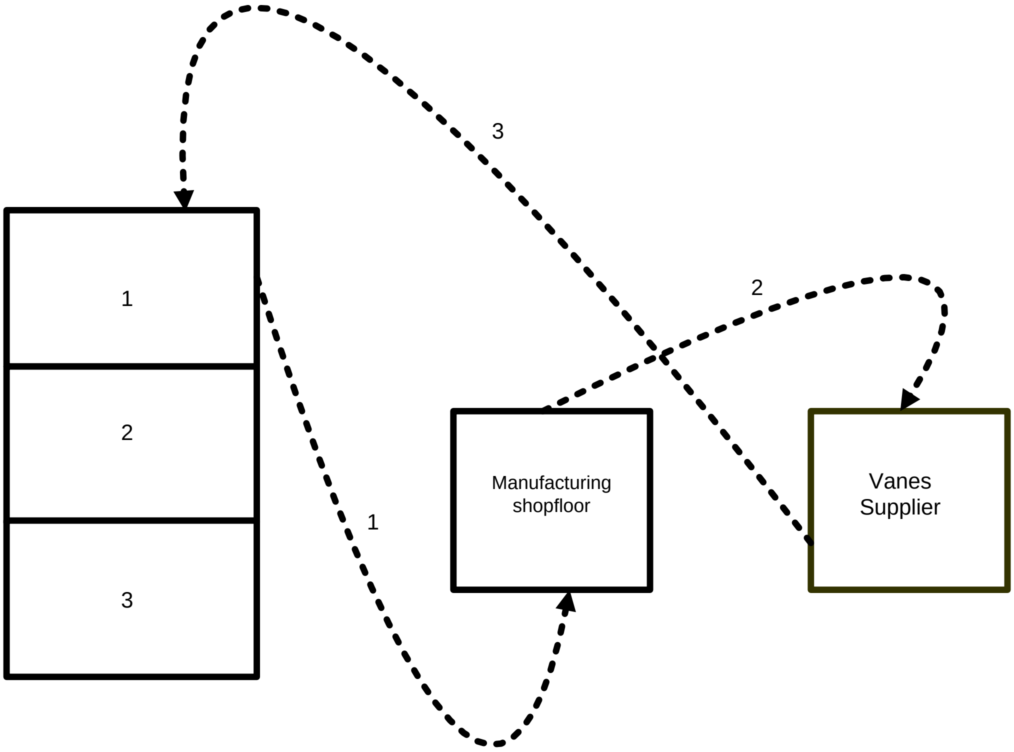


Figure 25: How the 3 bin Kanban for Vanes supply works

Picture 15: Vanes storage before

Picture 16: Vanes storage before - unimpressive

5.4.3 Material planning Spreadsheet

As noted in earlier sections, the case study company works on a 5-week lead-time and uses a spreadsheet (Unit Order scheduler) for determining likely despatch dates and for keeping within the company's production capacity. **Table 13** illustrates how the system works. For example, capacity for week 6 has been used up completely by both Export and UK sales department. In week 7, U.K is still allowed another 4 units. In week 8, Export received an order for 160 units but can only get 145 made. The remaining 15 units have to go into the column for week 9. In the same way, U.K Sales received an order for 20 units; 15 of these can be manufactured but 5 out of the 20 units must be postponed till week 9.

	Wk6	WK7	WK8	WK9	WK10	WK11
Export	145	145	145	20		
UK	15	11	15	5		
Total	160	156	160	25		

Table 13: Illustration of how the Unit Order schedule works

Table 14 displays a redacted copy of Unit Order schedule sheet for illustration. Information contained in it is used by Operations Director to plan production and allocate resources. The table showed that a total of 215 units were required, which comprised of 45 US5, 78 US2, 28 US9, 3 K32, 17 K4, 22 K5, 4 K62, 6 K7, 12 K2 and 1 K4 stainless steel.

For Assembly purpose, the order is treated as 45 US5, 78 US2, etc. however, for manufacturing purposes they are not strictly treated as separate products. Instead they are broken down and the various constituent subassemblies grouped (batched) together according to similarity i.e. based on the bill of material file (BOMF). Thus, an order for 6 K7 and 4 K62 is not sent down to manufacturing department to be produced separately. Instead, the Operations Director breaks it down and translates it into a build order[8] of 10 K7 S3s, 10 K7 Cases, 6 K7 S1s and 4 K62 S1s.

Doc No.	Order	Customer	Unit Type	Qty	Ack.Date	Wk.	Est. Date	
						42	19.10.07	
EXPORT								
8…6	Omitted due to confidentiality	Omitted due to confidentiality	FX550	45				
8…96			FX275	78				-
82340			FX900	28				
8….47			K32	2				
			K4E	2				
			K5E	2				
			K62E	1				
			K7	1				
			K7E	1				
82…2			K2	10				
			K4	10				
8…68			K5	20	Added with R's permission to go with 15 K4 built in wk. 43			
		Export	**200**					
UK		Omitted due to confidentiality		0				
79789			K7F	1		42		
82438			K7UK	1		42		
79953			K7F	1		42	Paint Unit Only BS20E51 Blue	
83124			K62EUK	1		42		
			K62	2		42		
			K5	1		42		
83152			K5UK	1		42		
82439			K4EUK	1		42		
83010			K4STUK	1		42		
82040			K4F	1		42		
83126			K4F	1		42		
			K32	1				
			K2	2				
TOTAL				**215**				

Table 14: Week 42 Unit Order schedule

[8] Every unit is chiefly composed of 3 subassemblies – S1, Case and S3

This is because K7 and K62 share the same Case and Drum (S3) but has different diaphragms (S1s). Manufacturing makes the 30 parts and ships to Assembly where they are eventually assembled into 6 K7 and 4 K62.

This type of practice is the most commonly used production method. Batch production is useful for manufacturing companies whose products' demand pattern are difficult to forecast. Other reasons include size of demand; for example small number of orders cannot justify investing in expensive machines required for continuous production lines. Also, a company operating in a niche market such as the case study company may not have the initial capital. Hence, the usual practice is to have a single production line that can be used to produce several products. Additionally, certain production process such as stamping, spinning, etc. lends itself better to batch production than to flow production.

In any case, batching makes sense in the case of the company mainly due to subassembly similarity and problems of shared resources. The company did not have an MRP system. Consequently, build-schedule batching was performed manually; this was time consuming, error prone and must be performed by someone who has a lot of product knowledge (usually, the Operations Director). Seeing how an MRP could improve the situation, the Author embarked upon creating a spreadsheet capable of mimicking salient features of one.

Initially, three worksheets were created, one for standard units, one for USA units and one for stainless steel versions of the standard units. Coloured lines and boxes were used to visual represent the various units and their shared bill of materials (shared components/parts). For example, K3, K6, K5 and K4 have orange coloured S3 boxes, indicating that they have the same S3 and so forth. **Figure 27** overleaf shows a screenshot of the manufacturing Material scheduling spreadsheet for standard units. By entering required quantity in boxes underneath the right unit type, correct subassemblies are generated.

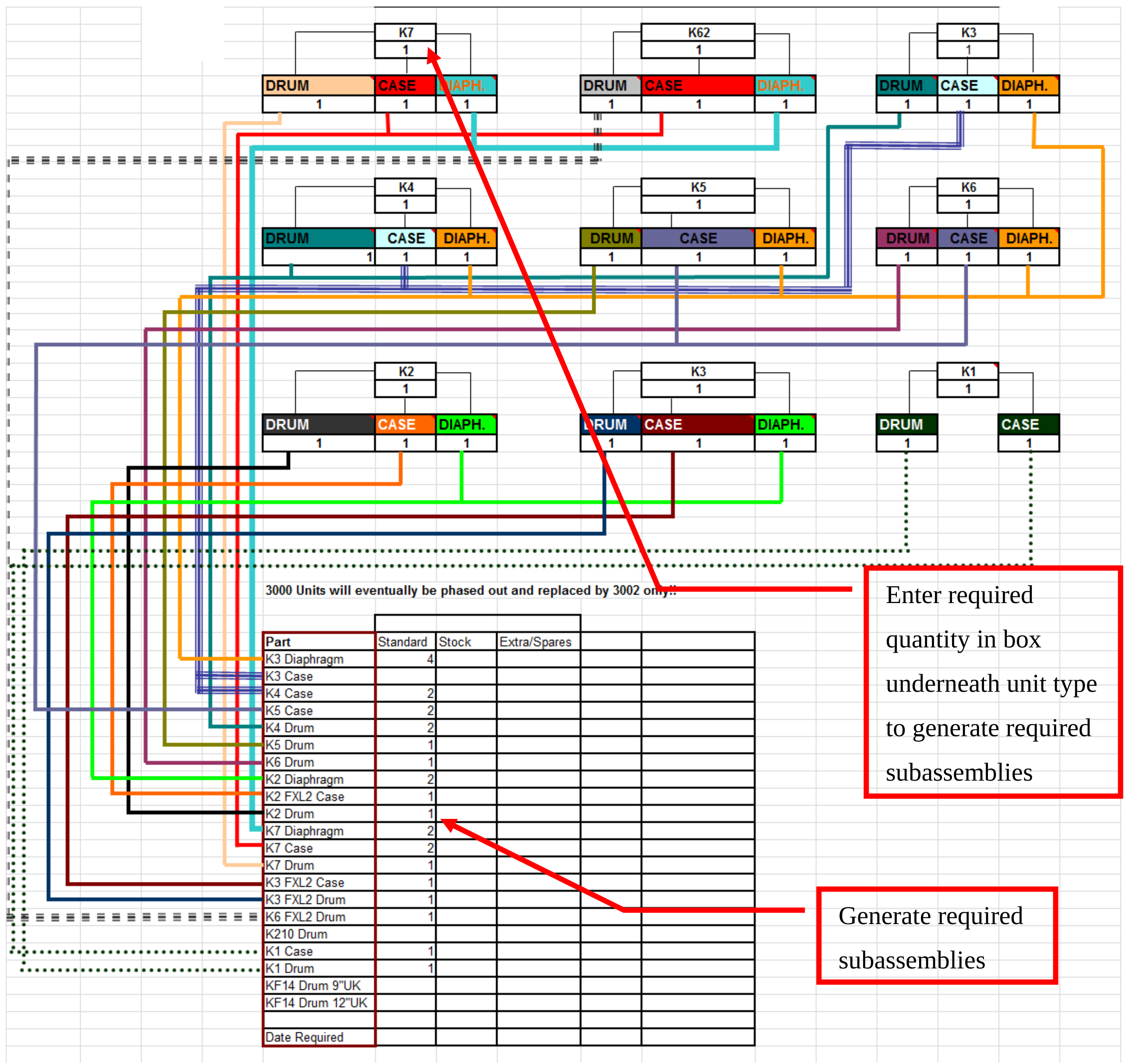
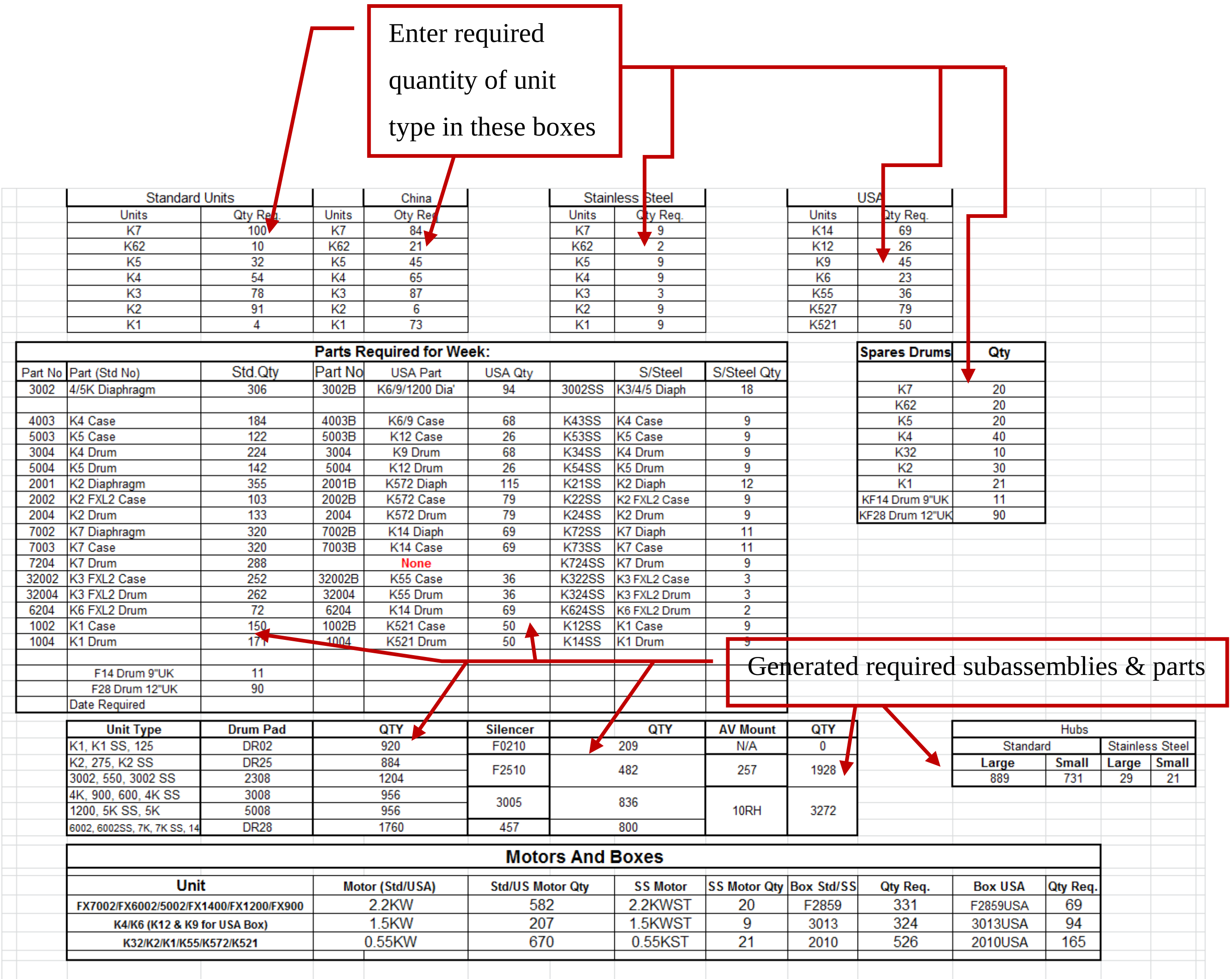


Figure 26: Screenshot of standard units' Manufacturing Material Scheduling Spreadsheet

The spreadsheet has since been amended, consolidated and debugged several times. **Figure 28** (shown below) is a screenshot of the latest version. As can be seen, it now has the capacity to generate schedules for all units and every required part.



Standard Units		China		Stainless Steel		USA	
Units	Qty Req.	Units	Qty Req	Units	Qty Req.	Units	Qty Req.
K7	100	K7	84	K7	9	K14	69
K62	10	K62	21	K62	2	K12	26
K5	32	K5	45	K5	9	K9	45
K4	54	K4	65	K4	9	K6	23
K3	78	K3	87	K3	3	K55	36
K2	91	K2	6	K2	9	K527	79
K1	4	K1	73	K1	9	K521	50

Parts Required for Week:

Part No	Part (Std No)	Std.Qty	Part No	USA Part	USA Qty		S/Steel	S/Steel Qty
3002	4/5K Diaphragm	306	3002B	K6/9/1200 Dia'	94	3002SS	K3/4/5 Diaph	18
4003	K4 Case	184	4003B	K6/9 Case	68	K43SS	K4 Case	9
5003	K5 Case	122	5003B	K12 Case	26	K53SS	K5 Case	9
3004	K4 Drum	224	3004	K9 Drum	68	K34SS	K4 Drum	9
5004	K5 Drum	142	5004	K12 Drum	26	K54SS	K5 Drum	9
2001	K2 Diaphragm	355	2001B	K572 Diaph	115	K21SS	K2 Diaph	12
2002	K2 FXL2 Case	103	2002B	K572 Case	79	K22SS	K2 FXL2 Case	9
2004	K2 Drum	133	2004	K572 Drum	79	K24SS	K2 Drum	9
7002	K7 Diaphragm	320	7002B	K14 Diaph	69	K72SS	K7 Diaph	11
7003	K7 Case	320	7003B	K14 Case	69	K73SS	K7 Case	11
7204	K7 Drum	288		None		K724SS	K7 Drum	9
32002	K3 FXL2 Case	252	32002B	K55 Case	36	K322SS	K3 FXL2 Case	3
32004	K3 FXL2 Drum	262	32004	K55 Drum	36	K324SS	K3 FXL2 Drum	3
6204	K6 FXL2 Drum	72	6204	K14 Drum	69	K624SS	K6 FXL2 Drum	2
1002	K1 Case	150	1002B	K521 Case	50	K12SS	K1 Case	9
1004	K1 Drum	171	1004	K521 Drum	50	K14SS	K1 Drum	9
	F14 Drum 9"UK	11						
	F28 Drum 12"UK	90						
	Date Required							

Spares Drums	Qty
K7	20
K62	20
K5	20
K4	40
K32	10
K2	30
K1	21
KF14 Drum 9"UK	11
KF28 Drum 12"UK	90

Unit Type	Drum Pad	QTY	Silencer	QTY	AV Mount	QTY
K1, K1 SS, 125	DR02	920	F0210	209	N/A	0
K2, 275, K2 SS	DR25	884	F2510	482	257	1928
3002, 550, 3002 SS	2308	1204				
4K, 900, 600, 4K SS	3008	956	3005	836	10RH	3272
1200, 5K SS, 5K	5008	956				
6002, 6002SS, 7K, 7K SS, 14	DR28	1760	457	800		

Hubs			
Standard		Stainless Steel	
Large	Small	Large	Small
889	731	29	21

Motors And Boxes

Unit	Motor (Std/USA)	Std/US Motor Qty	SS Motor	SS Motor Qty	Box Std/SS	Qty Req.	Box USA	Qty Req.
FX7002/FX6002/5002/FX1400/FX1200/FX900	2.2KW	582	2.2KWST	20	F2859	331	F2859USA	69
K4/K6 (K12 & K9 for USA Box)	1.5KW	207	1.5KWST	9	3013	324	3013USA	94
K32/K2/K1/K55/K572/K521	0.55KW	670	0.55KST	21	2010	526	2010USA	165

Figure 27: Screenshot of latest version of Manufacturing Material Scheduling Spread sheet.

Standard And USA				
Product	**Product Parts Description**	**Gross Required**	**Available**	**Net Req.**
Drums				
K7	Part 1	429		-429
	Part 2	429		-429
	Part 3	889		-889
	Part 4	1716		-1716
	Part 5	5148		-5148
	Part 3	1152		-1152
K62	K62 Vanes	564		-564
K5	Part 1	168		-168
	part 2	460		-460
	Part 3	672		-672
	Part 4	672		-672
	Part 5	1344		-1344
K4	Part 1	292		-292
	Part 2	1168		-1168
	Part 3	1168		-1168
	Part 4	2336		-2336
K3 FXL2	Part 1	298		-298
	Part 2	510		-510
	Part 3	731		-731
	Part 4	1192		-1192
	Part 5	1192		-1192
K2	Part 1	212		-212
	Part 2	848		-848
K1	Part 1	221		-221
	Part 2	221		-221
	Part 3	884		-884
Cases				
K7	Part 1	389		-389
	Part 2	389		-389
	Part 3	389		-389
	Part 4	789		-789
	Part 5	12148		-12148
	Part 6	1259		-1259
	Part 7	4566		-4566
	Part 8	4566		-4566
	Part 9	12148		-12148
K5	Part 1	148		-148
	Part 2	148		-148
	Part 3	870		-870
K4	Part 1	252		-252
	Part 2	252		-252
Old K3 & K600	Part 1	68		-68
	Part 2	68		-68
K3 FXL2	Part 1	288		-288
	Part 2	288		-288
K2 FXL2	Part 1	182		-182
	Part 2	182		-182
K1	Part 1	200		-200
	Part 2	200		-200
	Part 3	200		-200
Diaph.				
K7	Part 1	389		-389
	Part 2	389		-389
	Part 3	389		-389
	Part 4	4566		-4566
Old K3/K4/K5 & K600	Part 1	400		-400
	Part 2	400		-400
	Part 3	400		-400
K2	Part 1	470		-470
	Part 2	470		-470
	Part 3	470		-470

Table 15: Complete parts required to manufacture a given number of units generated by the Manufacturing Material Scheduling Spread sheet.

The system also automatically generates every single part such as studs, vanes, case blank, lid blank, oil rings, flanged formed nuts, etc. required by Manufacturing to produce any given number of the company's units. Some demonstration of this capability is demonstrated in **table 15.** The system is now used to generate purchase orders for manufacturing. It certainly made the task of batching up subassemblies and parts easier, much less time consuming and error-prone.

5.4.4 Template for Small Batch production

A build-schedule for week 42 (**tables 16 and 17**) generated by the Manufacturing Material Scheduling Spreadsheet is displayed below to illustrate how subassembly build-authorisation was previously conducted.

Parts Required for Week:			
Part (Std No)	Std.Qty	USA Part	USA Qty
4/5K S3	39		28
K4 Case	15		28
K5Case	24		0
K40S1	15		28
K5S1	24		0
K2 S3	15		123
K2 FXL2 Case	12		78
K2 S1	12		78
K7 S3	9		0
K7 Case	9		0
K7 S1	5		
K3 FXL2 Case	3		45
K3 FXL2 S1	3		45
K6 FXL2 S1	4		0
K1 Case	0		0
K1 S1	0		0
F14 S1 9"UK	0		
F28 S1 12"UK	0		
Date Required			

Table 16: Subassemblies scheduled for week 42

Parts Required for Week:	
Total Req.	Rounded Nr
67	70
43	45
24	25
43	45
24	25
138	140
90	90
90	90
9	10
9	10
5	5
48	50
48	50
4	5
0	0
0	0
	0
	0
642	**660**

Table 17: Rounded up parts

Table 16 shows quantities of required subassemblies; this would be sent down to Manufacturing where the operatives would normally round the parts up to the numbers shown on the right (table 17). Thus, instead of 642 subassemblies (i.e. 642/3 = 214), they would normally be rounded up to 660 (shown at the bottom of table **17**). Typically, the operatives would roll, seam weld, hammer and file all 90 K2 Cases, then all 50 K32 cases, all 45 K4 case and so on. They might also start with the S1s and carry on in a similar manner. The spinners would typically spin all 90 K2 cases before changing to 50 K32 cases. All 140 K2 S3s would be processed as a batch as would all 90 K2 S1s.

The result however, were mountains of in-process inventory (WIP) clogging up the whole factory space as the parts wait their turn in the queue to be processed. Most workstations usually have half- finished parts waiting to be processed. It is usually not possible to balance output as the subassemblies follow varying processing routes.

The other outcome was receipt of the subassemblies at neither the right time or at the right quantity by Assembly department. Mostly, Assembly department experienced either feast or famine. For examples, processing all 140 K2 S3s, 90 K2 S1s and 90 K2 cases means that Assembly will have enough subassemblies to complete the unit order for K2 and 50 S3s for K32 but no cases and S1s to complete the order for the required 48 K32. It takes only a little extrapolation to see how above case in point resulted in the earlier state of affairs whereby the Assembly shopfloor was often filled to the brim with subassemblies but not the right ones to complete necessary customer orders. The situation without a doubt also contributed most to the long lead times since there is a strong relationship between material queue and lead-time. In modern manufacturing (Lean) overproduction and queue time are known as the two greatest evils; focusing on reducing them usually results in dramatic improvement. Ways of achieving this include levelled scheduling (i.e. a mix of product every day or every week as required by the customer), and batch size reduction.

Having done the necessary ground task such as set up reduction, capability development (e.g. Hand Lathe was retrofitted; grub screw fastening improved, improvement, and so forth) there was no longer any excuse for not implementing small batch production. A small batch production schedule template was prepared and illustrated using the build-schedule for week 42. The aim was to produce a schedule that provides Assembly department the correct batch of S1–Case-S3 on a daily basis. The correct number of units required by Assembly was found to be approximately 40 units a day. Hence, to complete those 40 units they need 40 S1s, 40 cases, and 40 S3s of whatever required unit from Manufacturing depart on a daily basis. Initially, transfer batch size was going to be strictly limited to a batch size of 20 per depot and would be controlled using pull-system as illustrated by the diagram below (**figure 29**).

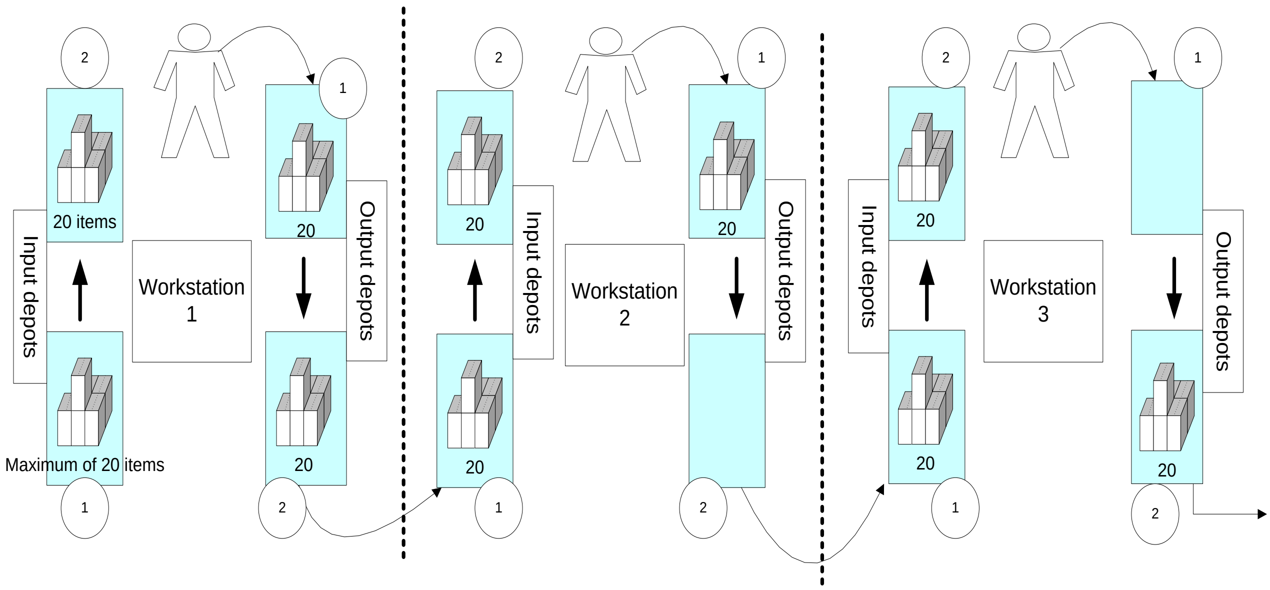


Figure 28: Batch size control

This scheme was later revised after taking workstation flexibility, problems of shared production facility, setup times, demand pattern, and the Operatives' appetite for change as well as other qualitative reasons such as the need to send out parts to subcontractors (e.g. powder coater). In addition, the manufacturing shopfloor do not have enough space for all the input and output depots required by every workstations. Additionally, the scheme would be hard to police. So, the Author took the decision to simply halve whatever the subassemblies requirement are, using increments of between 5 and 10 while bearing in mind the mantra a "mix of product every day or every week as required by the customer".

The table below (**table 18,** which has been redacted due to confidentiality) shows a mixed product production schedule prepared for illustration.

Parts Required for Week:					**Parts Required for Week 42:**		Breaks down to:		Sequence Required			Remaining
Part (Std. No)	Std.Qty	USA Part	USA Qty		Total Req.	Rounded Nr	K2 Drum	90		K2 Drum	50	40
4/5K Diaphragm	39	K6/9/1200 Diaph.	28		67	70	K2 Case	90		K2 Case	50	40
							K2 diaphragm	140	**1**	K2 Diaphragm	50	90
K4 Case	15	K6/9 Case	28		43	45						
K5 Case	24	K12 Case	0		24	25			**2**	K2 diaphragm	50	40
K4 Drum	15	K9 Drum	28		43	45				K2 Case	40	0
K5 Drum	24	K12 Drum	0		24	25				K2 Drum	40	0
K2 Diaphragm	15	K572 Diaph	123		138	140						
K2 FXL2 Case	12	K572 Case	78		90	90			**3**	K2 diaphragm	40	0
K2 Drum	12	K572 Drum	78		90	90	K32 Drum	50		K2 Drum	50	0
K7 Diaphragm	9	K14 Diaph	0		9	10	K32 Case	50		K32 Case	50	0
K7 Case	9	K14 Case	0		9	10						
K7 Drum	5	**None**			5	5	K62 Drum	5	**4**	K62 Drum	5	0
K3 FXL2 Case	3	K55 Case	45		48	50	K7 Drum	5		K7 Drum	5	0
K3 FXL2 Drum	3	K55 Drum	45		48	50	K7 Diaphragm	10		K7 Case	10	0
K6 FXL2 Drum	4	K14 Drum	0		4	5		10		K7 Diaphragm	10	0
K1 Case	0	K521 Case	0		0	0	K4 Drum					
K1 Drum	0	K521 Drum	0		0	0	K4 Case	45	**5**	K4 Drum	45	0
							K4 Diaphragm	45		K4 Case	45	0
F14 Drum 9"UK	0					0		70		K4 Diaphragm	45	25
F28 Drum 12"UK	0					0						
Date Required							K5 Drum	25	**6**	K4 Diaphragm	25	0
							K5 Case	25		K5 Drum	25	0
										K5 Case	25	0
			Total		**642**	**660**	**Total**	**660**		**Total**	**660**	**0**

Table 18: Small batch scheduling template

In the table, the numbers in “Parts-Req.” column are obtained by adding numbers in “Std.Qty” column to those in “USA.Qty” column. For example the quantity 67 is obtained by adding 28 to 39 because K4/5K and S3 is the same as K6/K9/K12 and S3. K6/K9/K12 and S3 is just the USA version of the standard K4/5K S3. Standard and USA versions are kept separate to indicate packaging and painting differences. USA versions are normally painted black and use a different cycle motors. Likewise “138” is obtained by adding 15 to 123. In the “Rounded” column, the numbers are rounded up or down for example, “24” cases (column 6, row 6) was rounded to 25 cases (column 7, row 6). Consequently, a total of 660 subassemblies will be manufactured instead of 642. The subassemblies are then gathered together according to unit type in the “Breaks down to:” section. For example, they became 90 K2 S1s, 90 K2 cases, 140 K2 S3s; 50 K32 S1s, 50 K32 cases…25 K5 cases.

The subassemblies are then sequenced in 6 stages in the “Sequence Req.” column starting with largest required unit (in this case K2). First, 50 K2 S1s are processed (leaving another 40 i.e. 90 - 50), followed by 50 K2 cases, then 50 K2 S3s (leaving 140 – 50 = 90). In the second stage, 50 K2 S3s are processed (leaving 90 – 50 = 40 S3s; note that this removes the need to setup for S3), followed by 40 cases, then 40 S1s. The sequence concludes at stage 6 when 25 K4 S3s have been processed, then 25 K5 S1 followed finally by 25 K5 cases.

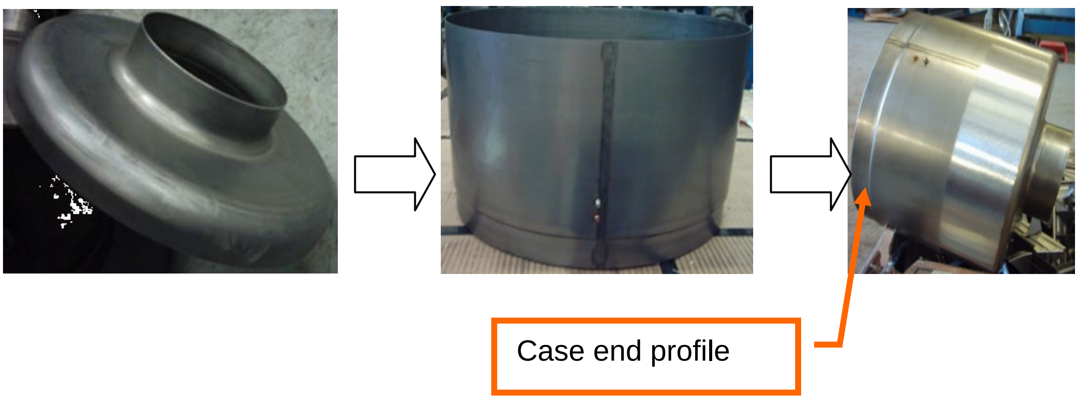
The template was offered to the Manufacturing Supervisor who promised to give the “split-build[9]” a try. But, the “split-build” never took off; it died quietly. It was revived however when the Supervisor went on holiday thus providing the Deputy Supervisor who is more forward thinking to successfully execute it. The successful implementation gave the Author the confirmation that reduced batch size and mix of product every day or every week as required by the customer works. Nevertheless, the method would not have become a reality without the Operations Director who has since insisted on it. Manufacturing operatives are no longer given just the list of the required subassemblies. They now receive the correct build-sequence as well.
The Operations Director has also successfully extended the small-lot method to Assembly department. Previously, Assembly Operatives would assemble as many units as can be fitted on the assembly benches. Now, the Operatives start, finish and package 10 units before starting on another batch of 10.

5.4.5 Results

The impact of the successful implementation of “small batch size and mix of product every day or every week as required by the customer” method was immediate and very positive. In one fell-swoop a majority of the desired outcome of the study was achieved including - space maximisation, workflow maximisation and stock reduction. Inventory level reduced dramatically, which meant less stock carrying costs. Due to confidentiality constraints exact figures on improvement could not specified but the huge amount of incomplete subassemblies at the Assembly shopfloor almost totally disappeared. More shopfloor space became available and the company started reporting more favourable lead times. The Operatives in particular the forward thinking Bill and John (the deputy supervisor) reported better workflow and less boredom. More importantly, Manufacturing Department started supplying Assembly Department with the required components, at the right time and right quantity.

5.5 New Spinning Method

There is a limit to the improvement that can be gained from motivation and optimisation techniques. After a certain stage, further improvements require rethinking the entire process and upgrading capital equipment and tooling. With this in mind, sanding of case after seaming welding lid to case body (shown below as **picture diagram 17**) operation was first targeted; the operation is very laborious, noisy, dirty and generally unpleasant. Jetline longitudinal and circumferential seam plannisher (shown as **picture 18**) was identified. The machine can roll out weld build-up resulting in excellent smooth surface finish and even enhances weld metallurgical properties by cold working “as cast” weld structure. It can also be used to roll out S1 body and case body (**shown as picture 19**) weld build up thus removing the need for filing and hammering before spinning operations.



Picture 17: Lid to case

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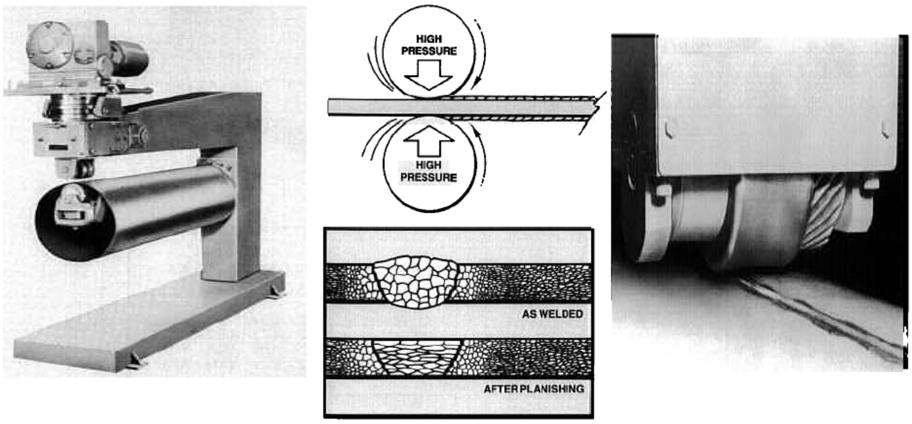
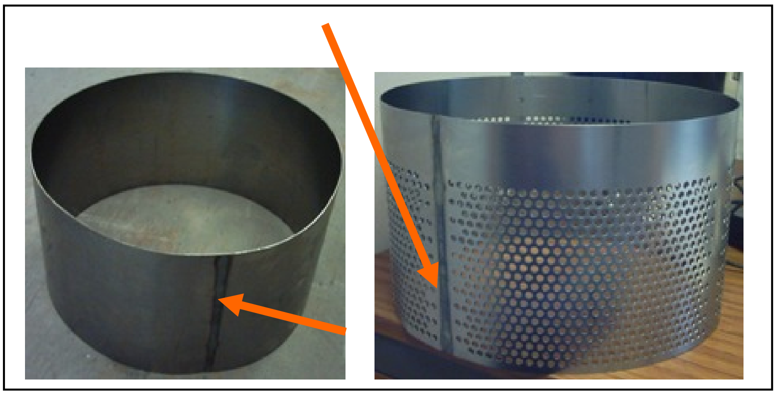
[9] The Supervisor’s own word for the reduced batch size method



Picture 18: Jetline longitudinal and circumferential seam plannisher



Picture 19: S1 and Case bodies must be hammered and filed before spinning operations

Next, attention was directed towards reducing spinning and welding operation durations. As shown in **figure 30** (figure on the left) below, lids and case bodies are welded lip to lip but this take time to jig up and requires considerable skills to weld and finish. Profiling the lip of the lid to create male-female joint so that the lid can slip into case body or vice versa (shown as **figure 30 – on the right**) to make setup, jigging and welding easier was considered. The suggestion was however discarded due to aesthetic reasons. Also, the resulting weld build-up still needs to be sanded off. In any case the Author was told that the idea has been tried before without success.

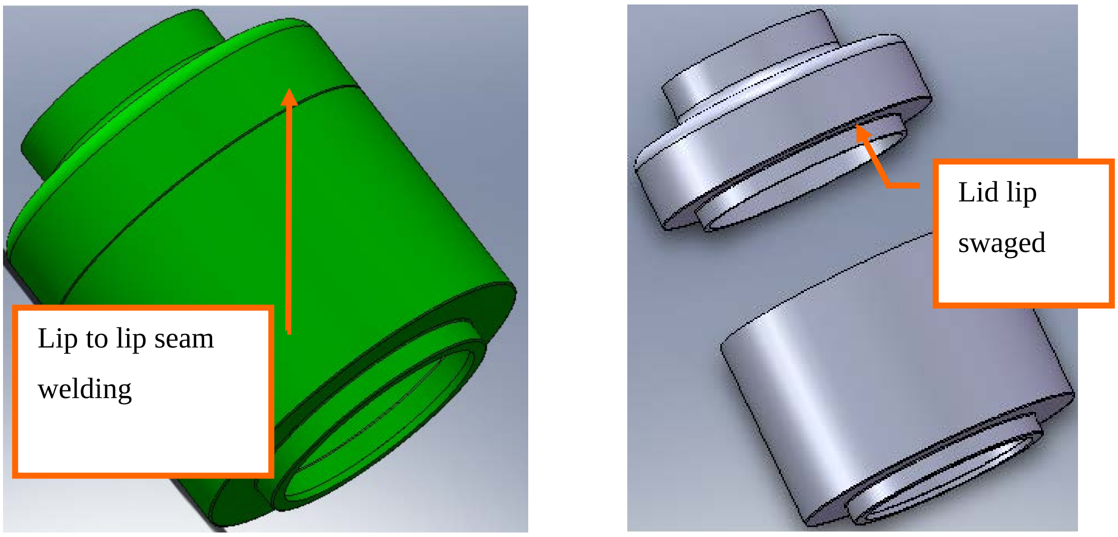


Figure 29: Swaging the lip would makings fitting and welding easier

The end profile on the Case was going to be achieved using PB Engineering's trimming and beading machine. Due to the versatility, the machine can also be used to produce other parts and products manufactured by the company such as the S1s and flange adaptor**.** The Flanging and Arch-bending machines can also produce some of the company's parts and products

Also, means of automating welding operations was also sought. Hot Wire (TIG) Automated Welding System like the type manufactured by Liburdi Dimetrics was identified as a possibility. However, the whole ideas despite their many merits were discarded due to reasons of cost and after screening them using Shingeo Shingo's framework (Shingo 1988a). Under this paradigm, there are differences between process and operation; process improvement is not gained by improving operations. Hence, buying a machine to improve sanding/dressing operation is operation improvement but not process improvement. A true process improvement would be total elimination of sanding/dressing operation.

Subsequently, the Author started wondering whether it would be possible to eliminate hammering and filing operation. Maybe even eliminate rolling and seaming, sanding/dressing operation altogether? Perhaps, take out TIG welding and possibly reduce the number of spinning steps? When this idea was first suggested to the manufacturing operatives it was dismissed as unworkable and impossible. The reason given is: "in spinning (**figure 33 – picture left**), a disc blank or pre-form is formed by progressively forming a disc blank onto a spinning chuck (forming tool) having the same shape as the desired part". For this reason, the spinning chuck must have a shape that allows ejection of the spun part after spinning otherwise the spun part cannot be discharged. Hence, a case cannot be ejected because it would be stuck against the spinning chuck as demonstrated by **figure 33 (picture on the right)**.

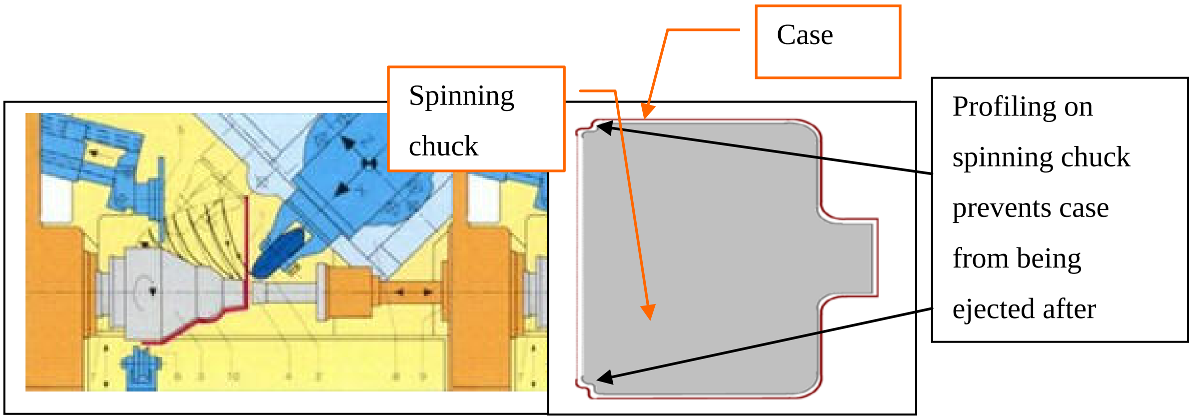


Figure 30[10]: Spinning operation; profiling on spinning chuck prevents case from being ejected after spinning

In order to overcome this problem, case-manufacturing process is performed as follows. First the blank is rolled, then seam welded, hammered and filed. Next, depending on the unit type, it is spun by Hand or with Power Lathe. The lid is spun with Numerical Control machine, and then the lid and case are joined together before being finished by sanding out.

[10] Courtesy of Leifeld Engineering

A number of ways to overcome this problem was analysed such as initially spinning the case without the end profile and then use secondary operation such as beading or swaging to end-profile it. Further studying of Spinning practice and information obtained from spinning machine manufacturers revealed that there are indeed solutions. A centrifuge whose casing is uncannily similar to K2 case was discovered. It was spun using a machine manufactured by Industrias Puigjaner (DENN), of Spain. Further research revealed that this manufacturer also manufacture stainless steel jars. The jars are in many ways similar to the case study company’s cases. The pictorial diagram below (courtesy of Industrias Puigjaner) illustrates how it was made (**figure 34**).

Figure 31: Stainless steel jar spinning

Additional investigation revealed further possible spinning methods such as spinning-on-air, deployment of internal segmented or eccentrically mounted tooling.

Figures 35[11] illustrate spinning-on-air (also called reducing or necking-in), and techniques of using internally segmented and eccentrically mounted tooling. In the diagram, re-entrant shapes where both form and finish are less important are spin-formed "on air", which means that the shape is produced with no internal support; the spinning chuck is not copied. The pre-form is externally clamped in a retaining chuck. Alternatively, where a higher quality is demanded, internal segmented tooling or, (if the geometry allowed) an eccentrically mounted tooling (sleeve support), and internal roller may be deployed.

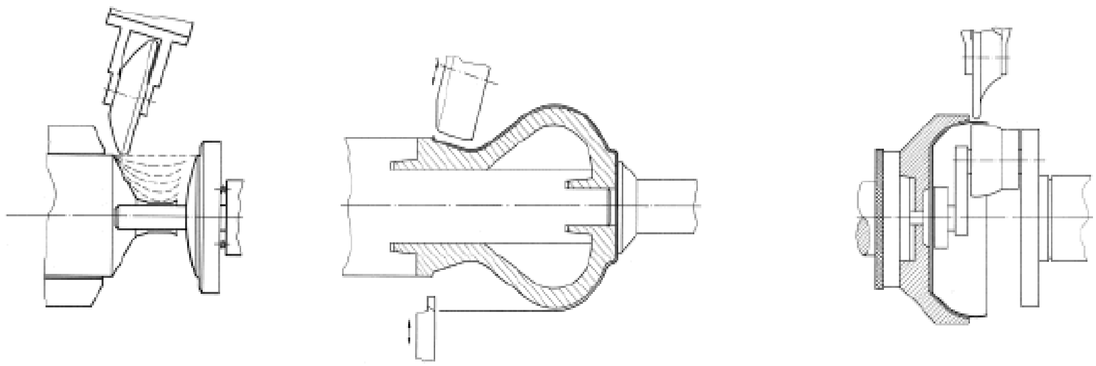


Figure 32: Illustrate spinning-on-air and techniques of using internally segmented and eccentrically mounted tooling.

Having gathered this information, the machine tool exhibition EMO2007, which took place in Hanover, was visited. There, several spinning machine manufacturers such as Mario Di Maio of Italy and Repkon of Turkey confirmed that spinning methods indeed exist that can be used to manufacture at least K2 and K32 cases without the need for Rolling, Seaming, Hammering, Separate case body spinning, Separate PNC Lid spinning, Tig welding, and Dressing/sanding.

The findings were followed by a visit to Leifeld (whose NC spinning machine the company already own) to investigate the issues raised such as tooling, costs, training and support. Leifeld cconclusively confirmed that K2 and K32 cases could be formed through innovative use of internally segmented and eccentrically mounted tooling.

[11] Illustration obtained courtesy of Leifeld

Following that visit and other negotiations, Leifeld quoted total costs of implementing the technique as **£48,703.00**. The costs include tooling, training and miscellaneous. Cost benefits analysis of implementing the technique was obtained by calculating money that would be saved by eliminating the 5 (K2 and K32) manufacturing operations (**table 19**[12]).

FX 2000		
Task/Operation	OPTime (mins/pc)	Hourly cost @ £0.25/min
1. Roll	0.58	£0.15
2. Se[illegible] & Hammer	2.40	£0.60
3. Ha[illegible] Spin	4.53	£1.13
8. 1st Stage Lid [illegible]NC Spin	2.60	£0.65
9. 2nd Stage Lid [illegible]NC Spin	2.20	£0.55
13. Tack Weld Lid to Case	6.00	£1.50
14. Tig Weld Lid to Case & Dress	5.10	£1.28
Total	23.41	£5.85

FX 3002		
Operation Time (mins/pc)	OPTime (mins/pc)	Hourly cost @ £0.25/min
1. Roll	0.58	£0.15
2. Seam Weld & Hammer	2.46	£0.62
3. Hand Spin	4.86	£1.22
8. 1st Stage Lic [illegible]NC Spin	2.60	£0.65
9. 2nd Stage Lid [illegible]NC Spin	2.20	£0.55
13. Tack Weld Lid to Case	6.50	£1.63
14. Tig Weld Lid to Case & Dress	5.20	£1.30
Total	24.40	£6.10

Table 19: Cost of operations that can be replaced by adopting new spinning technique

Total operation time of present methods: 23.41 minutes for K2 + 24.40 for K32

= 47.87 minutes (*see table 19 above*)

Total costs of present method: £5.85 + £6.10

= £11.95 (*see table 19 above*)

Expected cycle time using new method = 5 minutes (*provided by the tool manufacturer*)

Hence, cost of the new method = £1.25 (i.e. 5 x £0.25)

So cost savings = £ 10.70 (i.e. £11.95 – £1.25)

Since project cost is **£48,703.00,** then Payback quantity = (£48,703.00)/£10.70

= 4551.68 units

Average monthly demand for K2 and K32 = 333 units

Consequently, the project will pay back for itself after 4551.68/333 = **13.67 months (under 2 years)**

Apart from the immediate payback of this project, other advantages can be seen. Important components of this study are reduction of lead-time, space utilisation, increased workflow, increased output/productivity and transfer of knowledge.

[12] Only for illustration

The 43 minutes saved as result of adopting the new method (not to mention the eliminated setup times) can be used to produce other things. Also 3 operatives would be freed up to perform other duties such as some of the outsourced jobs, which could be brought back. Other gains include:

- Consistent quality – no more visible seams and lumps, possible leaks, etc.
- Reduced handling.
- Reduced ordering cost e.g. 1 blank ordered instead of 2 separate blanks
- Vastly reduced space requirement.
- Vastly reduced WIP (work in progress)
- Reduced stock carrying cost.
- Greater flexibility.
- Reduction in lead times.
- The company can take advantage of an expanding market opportunity and sell more of their products since this new spinning method will expand production capacity as well as response time.
- Knowledge will pass from people to machine (a good thing for the company).

These analyses were presented to the company; they accepted the arguments in its favour and are presently considering the implementation.

5.6 Increasing capacity by employing an extra manufacturing operative

During one of the many informal meetings between this Author, the manufacturing Supervisor and the deputy supervisor the merits of employing an extra manufacturing Operative as means of gaining further capacity was debated. The new Operative would be responsible for all press operations such as punching holes on S3s, drilling holes on lids, which is normally an outsourced operation. The new operative will also perform other duties as may be required. Quantitative examination of the case indeed strongly suggested several advantages. The arguments in favour of employing a labourer are presented below. Presently, outsourcing hole drilling on lids cost the company £1 per lid; approximately 8000 lids are sent out per year.

Hence cost of holes is £1 x 8000 = £8000

The new Operative will cost £6.00 per hour

Normal working hours per week = 39 hours

Hence, working hours per year = 52 x 39 hours

And so, cost of new Operative = £6.00 x 39 x 52

= £12168.00

Add NHS = £12168.00 x 1.13

= £13749.84.

Thus, actual cost to the case study company of employing the new Operative

= £13749.84 - £8000.00

= £5749.84

The company will have to invest in a punching tooling, which costs approximately £200.00. This is recoverable after just 200 units or within a week and a day i.e. 200 units/£1 spent drilling each lid. Apart from punching holes on lids, the new Operative will be responsible for every press operation. This will release the 3 welders to concentrate on welding.

Presently, the 3 welders cost (3 x £11 x 39 x 52) x 1.13 = 75624.12

Based on 39 hours week, working hours per year = 52 x 39 hours

= 2028 hours per year

Hence their combined cost per hour = £75624.12÷2028 hours

= £37.29 per hour or £12.43 per hour for each welder

Hourly cost of the would be Operative = £13749.84÷2028 hours

= £6.78 per hour

Approximate time currently spent on all press work per unit = 12 minutes (or 0.2 hours)

So cost of one welder doing press work = £2.5 (i.e.0.2 hours x £12.43)

Cost of all 3 welders doing presswork instead of welding = £7.5 (i.e. £2.5 x 3)

Cost of 8000 units per year per welder = £20,000.00(i.e. 8000 x £2.5)

Since all welders are usually doing their own presswork at the same time, then actual cost is 8000 x (£2.5 ÷ 3) = £6666.67

Cost of the new Operative doing presswork per unit

= £1.4 (i.e. 0.2 hours x £6.78)

So, new Operative cost for 8000 units = £11200 (i.e. £1.4 x 8000)

Comparing this to the ££6666.67 that the 3 welders currently cost, the case study company will not be losing £5749.84 as first suggested but will be saving:

(£8000 + £6666.67) - £11200 = £3466.67

Other benefits include increasing output by at least 20 units per week (negotiated with the shopfloor operatives), reduced paperwork, reduced lead-time due to improved flexibility, space maximization due to reduction of in-process inventory, etc. Additionally, the would-be Operative can assist with spot welding tasks or carry out rolling, seam welding and hammering operations while the delivery driver (who also doubles as rolling, seam welding and hammering operator) is out on his rounds.

From process improvement viewpoint, workflow would importantly improve since queue time will be eliminated. As soon as lids come off the PNC, they are immediately processed. Presently, the lids wait for sufficient quantities to accumulate, and then wait for delivery driver to send them out, and then wait for the Subcontractor to process them, and then wait for delivery driver to bring them back, etc. Flexibility and small batch production would be further enhanced since there would be no need to wait until there are sufficient lids to warrant sending out. Space would be maximised and time devoted to processing the paper work would also be eliminated.

5.6.1 Results

The analyses were presented to the management who immediately gave their approval. A new Operative was subsequently employed and output has gone up as predicted (now around 230 units per week). This concluded the last major work done at the manufacturing area of the company. Attention was next directed to Assembly shop floor.

5.7 Conclusion

As has been demonstrated in this section identifying and applying appropriate tools of process improvements such as those used in Lean Manufacturing can solve manufacturing problems of SMEs such as those suffered by the case study company. However, deploying these tools involve significant changes to the way the manufacturing operatives operate and certainly threaten established power relationships. Thus, conflicts and resistance encountered in this study can be interpreted as a case of one power fighting another to change the status quo. Resistance occurs naturally as a reaction to change especially when that change impinges on a valued resource, position or power, or means expending effort, or there is disagreement about which change to implement, who should implement that change, and the timing of it. Change happens if aspirant power defeat vested power or if old and new powers are synthesized into a new form of power relationship. Those who wish to bring change to an organisation must reckon with opposition from those currently benefiting from the system. Such oppositions can take all forms and can easily degenerate into negative political behaviours such as sabotage and skulduggery. The ability of one party to gain the upper hand depends on how much power the party can call upon. Hence power is very important to understanding and dealing with resistance. Consequently, knowledge of organization politics should be in the munitions store of those wishing to implement process improvement.

It is important to analyse and understand the alliances, coalitions, power bases and power sources operating in an organisation for this is what will enable those wishing to introduce process improvement into an SME to devise means of redressing the balance of power. In this study, this knowledge was used to debunk the myth of scarcity (i.e. of knowledge) and reduce the condition of dependence the manufacturing operatives created. For example, the case for introducing a new spinning method was made not mainly to show its technical superiority to current method but to demonstrate a substitute to the operatives' skills. It shifted the balance of power away from the operatives i.e. via the reduction of the condition of dependence (non-substitutable skills) they imposed on the case study company. It worked completely because thereafter cooperation from the operatives became even easier.

Power however should be used subtly because that is when it yields best results. When power is not used delicately, those at the receiving end of its effects may feel that they have nothing to lose and resist. This is the opposite of what is intended. Thus, in this study consultations and negotiations as well as appeal to emotion, sensitivity, and interpersonal influencing tactics such as managing constructive relationship with all stakeholders, developing alliances, using the technique of two step leverage, anticipating the response of individuals to events were used a lot to obtain goal congruency. Timing when to bring in the various process improvement tools as well as doing so incrementally (short term wins) such that any opposition will be unprepared were political tactics used. Thus the political approach made the deployment of those operational tactics of modern process improvement possible. This would have been otherwise difficult if not impossible. As has been demonstrated equilibrium of power (rather than peoples' good nature alone) contributes most to harmonious relationship in an organisation. The political approach is a mean to attaining such equilibrium of power.

Chapter 6

Assembly Optimisation

As already mentioned, the case study company have considerable experience and expertise in Assembly but no in Manufacturing. It should be noted however, that this expertise is of informal nature since the steps were not formally documented. Neither have anyone analysed the steps to see where improvements can be obtained. Consequently, improving Assembly process and operations was not deemed important by the company. Nevertheless, the company decided to use opportunity afforded by the project to:

1. Improve quality by reducing assembly errors.
2. Capture and formalise Assembly procedure/operation steps.
3. Capture operation times.
4. Use these captured operation durations to determine quantitatively the key resources needed to meet market demands such as the number of operatives and minimum number of workstations.
5. Improve tidiness as well as health and safety.
6. Balance the workstations and formalise the Assembly layout by determining formally which space is no longer required for assembly purpose and work-in-progress.

6.1 Improving quality by reducing assembly errors

Unlike Manufacturing, the Assembly department uses a lot of temporary workers. The first task usually given to these temporary workers tend to be fastening of latches and clips to cases. The instructions on how to perform these tasks were given verbally; thus due to lack of experience and lack of a written instruction to refer to they make a lot of mistakes.

Consequently, in order to improve this operation and to reduce the quality problems, instruction manuals were designed, tested and introduced to help with training any new operative and to ensure that everyone perform their work in the same way.

Round about the time of the Assembly process investigation, the department also started experiencing many other embarrassing quality problems. For example, the Operatives on occasions forgot to tighten fasteners to correct torque, which resulted in many angry customers and complaints. The solution suggested and accepted by the author is introduction of a standard assembly instruction that contains all the necessary steps as well as the quality checks that must be performed. The author prepared the manual using inputs from the operatives, the case study company's Quality Consultant, and the Operations Director. It was validated by giving it to two people who normally do not have anything to do with Assembly. They successfully used the manual[13] to assemble some units; thus confirming that the manual is accurate.

6.2 Capturing and formalising Assembly procedure/operation steps

Similarly to the method used at manufacturing shopfloor, work measurement at Assembly area of the company started with participative observation. The Author joined the operatives and carried out all the assembly operations. This provided a chance to appreciate what improvements are needed.

Assembly workflow diagrams were generated. Durations of each work element were captured over several weeks; these were then averaged to obtain average time per assembly operation. **Table 20** below shows the captured work elements, task precedence and duration of each task. For example, assembly task 4 does not depend on any task but assembly tasks 5 to 11 can only be performed after task 4. In the same way assembly task 12 does not depend on any other assembly task.

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[13] None of the written instructions and assembly manuals can be shown here due to commercial sensitivity and confidentiality.

Tasks and Average Durations for Assembly Operations			
OP.Nr	**Operation**	**Tasks That Must Immediately Precede**	**Time to Perform Task (minutes)**
1	Task 1 (True-up drum – not normally Assembly task)		2.30
2	Task 2	1	1.66
3	Task 3 (balance drum)	1, 2	4.33
4	Task 4		0.20
5	Task 5	4	0.33
6	Task 6	4, 5	0.30
7	Task 7	4 to 6	0.20
8	Task 8	4 to 7	0.13
9	Task 9	4 to 8	0.08
10	Task 10	4 to 9	0.13
11	Task 11	4 to 10	0.08
12	Task 12		1.42
13	Task 13 (Motor to Diaphragm)	4 to 12	0.10
14	Task 14	4 to 13	0.53
15	Task 15	4 to 14	0.18
16	Task 16	1 to 3 and 4 to 15	0.20
17	Task 17	1 to 16	0.17
18	Task 18	1 to 17	0.37
19	Task 19		1.58
20	Task 20 (Mount case on motor-diaphragm subassembly)	1 to 18 and 19	0.73
21	Task 21	1 to 20	0.43
22	Task 22	1 to 21	0.17
23	Task 23	1 to 22	0.23
24	Task 24 (affix label 1)	1 to 23	0.30
25	Task 25 (affix label 2)	1 to 24	0.37
26	Task 26 (affix label 3)	1 to 25	0.37
27	Task 27 (affix label 4)	1 to 26	0.37
28	Task 28 (affix label 5)	1 to 27	0.90
29	Task 29 (affix label 6)	1 to 28	0.72
30	Task 30 (transfer unit to testing area)	1 to 29	0.44
31	Task 31 (prepare documents)	1 to 30	0.54
32	Task 32 (test units)	1 to 31	0.55
33	Task 33 (input unit's information and test data to system)	1 to 32	0.60
34	Task 34 (affix label 7)	1 to 33	0.54
35	Task 35	1 to 34	0.54
36	Task 36 (Move to Packing Area)	1 to 35	0.21
37	Task 37 (make accessories)		4.50
38	Task 38 (make foam)		4.14
39	Task 39 (Pack Unit)	1 to 38	2.53
	Total		**33.47**

Table 20: Assembly operation times

The Author personally performed all the operations hence can confirm the accuracy of the task times. Having obtained this information, Line balancing calculations were performed in order to primarily determine output rate to meet customer demand, determine the minimum number of work stations and to balance the stations so that idle time is minimised.

The calculations showed that the target output rate of 235 units per week is achievable using 3.36 (rounded to 4) balanced workstations working on a cycle time of 9.96 minutes even after "true-up" (normally a Manufacturing operation) is included in Assembly operation. The calculations are displayed below:

Time available: 39 hours

Quantity required: 235 units

Output rate (r): 235 ÷ 39 = 6.025641026 units per hour

Cycle time: 1÷ r = 1 ÷ 6.0256 = 0.165957 or 9.957 minutes per unit (i.e. 0.1659 x 60)

Total operation time: 33.47minutes

Hence, number of workstations = 33.47 ÷ 9.96 = 3.36

Utilisation = (3.36 ÷ 4) x 100

= 84% (i.e. Minimum number of work stations)/ (Actual number of work stations)

NB: We could have also obtained Utilisation or efficiency as follows:

$$\frac{Total\ task\ times}{Number\ of\ stations\ \times cycle\ time} \times 100$$

$$= \frac{33.47}{4 \times 9.96} \times 100$$

= 84%

6.3 Balancing the workstations and formalising the Assembly layout

The diagram overleaf (**figure 36**) shows present Assembly line plant layout. Assembly tasks are performed in 7 stages on 3 long workbenches, at a foam making station and at a balancing machine. The stages include diaphragm preparation, case preparation, motor preparation, drum preparation, foam making, labelling, testing documentation as well as packaging. Diaphragm and case preparation are performed on table 1. Foams are produced beside table marked 1 at the foaming station. Motors are prepared on table marked 3, while drums are prepared and balanced at station marked 4. The cases, drums and diaphragms are then brought to table 3 and fitted to motors. Table 2 used to serve as a holding place for work-in-progress but has become more or less redundant because the Operations Director limited transfer Assembly batch size to a maximum of 10 units after noticing the success of small batch method implemented on the Manufacturing Shopfloor. Thus, no more than ten units are allowed on the Assembly space at any time.

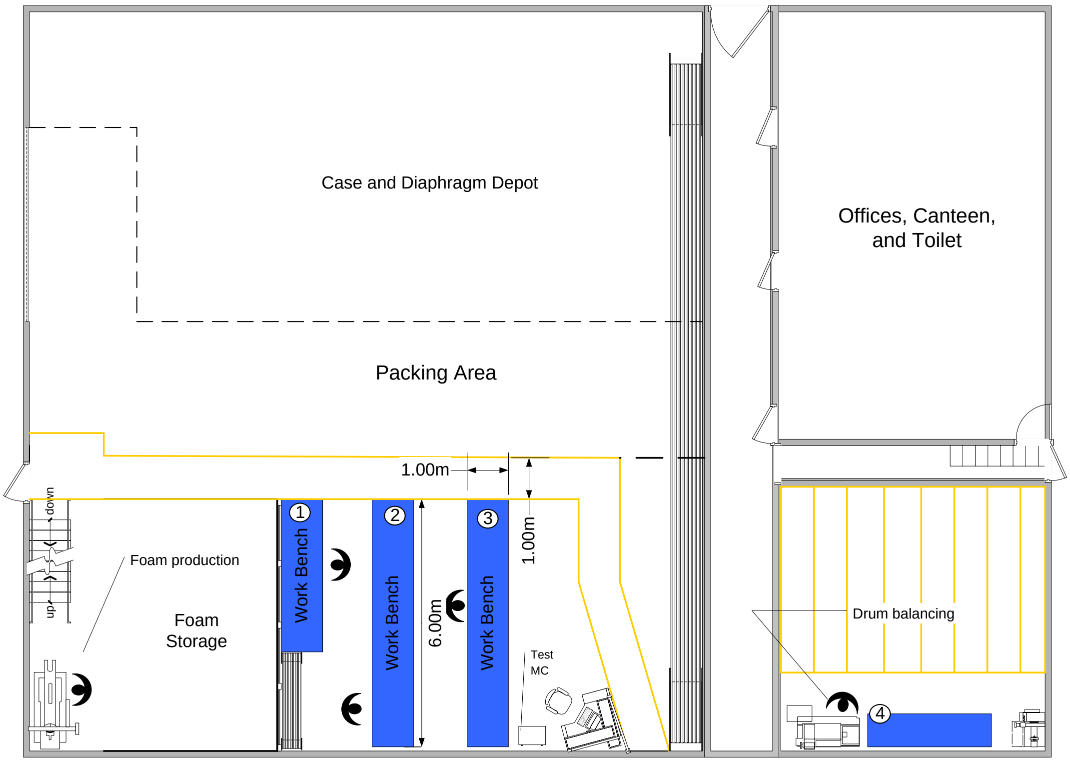

Figure 33: Illustration of present assembly line layout

Using the results of the calculations above, a new Assembly layout was developed, balanced (**figure 37**), and optimised using incremental utilisation heuristic method. This is achieved by assigning tasks to centres (or work centres), strictly following the sequence of tasks. Tasks were combined in sequence until the utilisation of the work centre became 100% or observed to peak and fall, and then a new work centre is started.

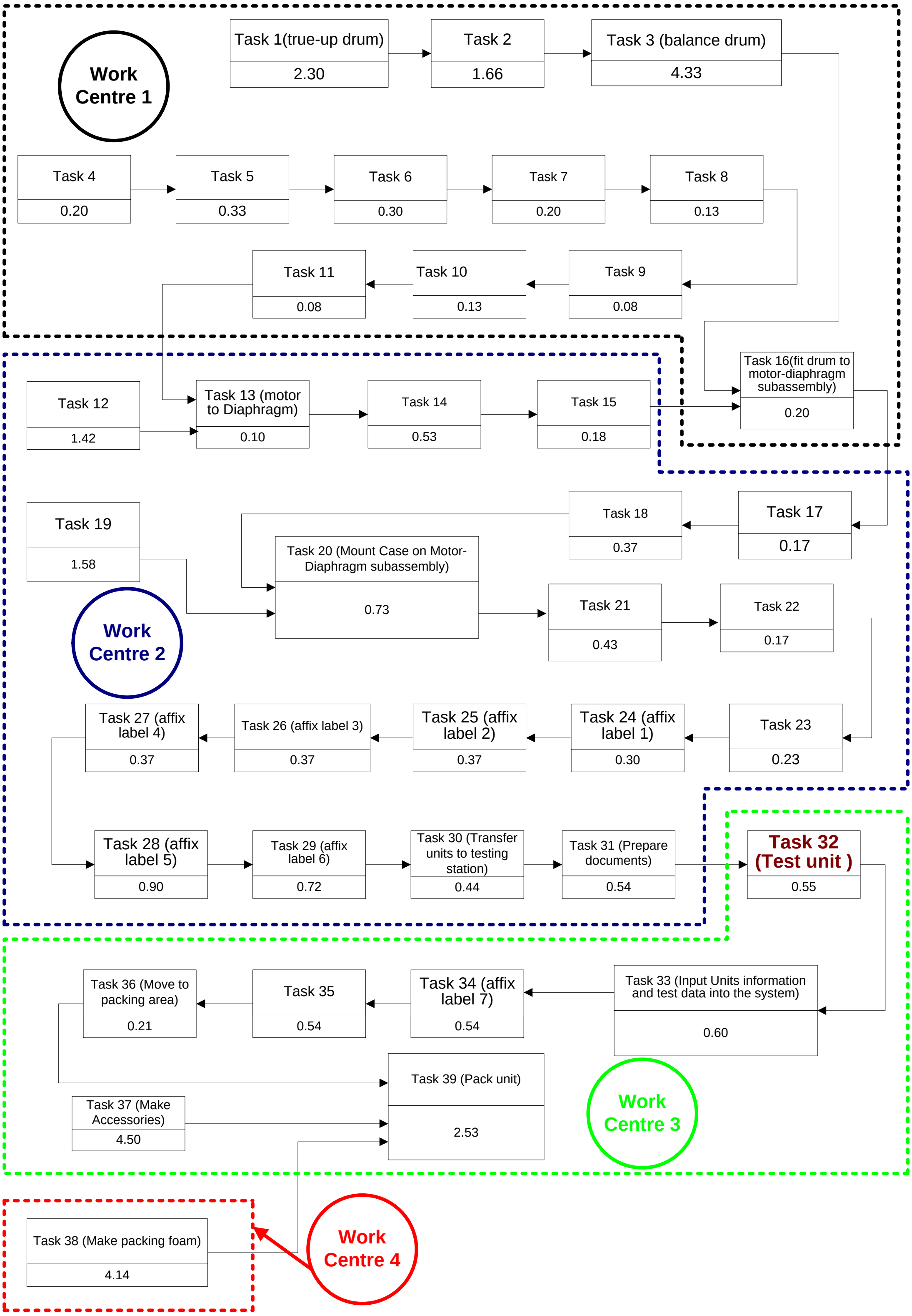

Figure 34: Balancing of the proposed Assembly Line

For example, the total task time for work centre-1 is 9.94, which gives an utilisation of (9.94 ÷ 10) x 100 = 99.4%. Adding any other available task will only reduce the utilisation of the centre; for example, assigning Task 15 to this centre will give a total task time of 10.12, which gives utilisation of 92% (i.e.10.12 ÷ 11 x 100).

Thus, summarising the assignment of tasks it can be seen as shown in **figure 35** that the entire Assembly tasks can be done in 4 work-centres as follows:

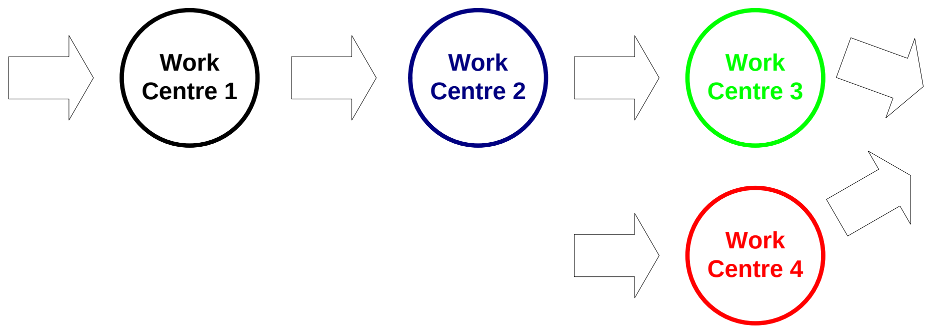

Figure 35: Assignment of task to work centres summary

6.4 Formalising the Assembly layout

It was not possible to collect data with which to perform Assembly layout redesign calculations such as load-distance analysis, and block diagram. This is because the case study company did not deem these necessary. In any case, they have a point since the Assembly shopfloor is not large and the distance between work stations were quite miniscule; apart from foam making and drum balancing all the other tasks are carried out at the same place. Also, since the adoption of the small batch method, lack of space was no longer a problem. Finally, while the company was willing to allow rearrangement of the workbenches and relocation of the balancing machine they did not want to relocate the foam making work centre due to the expense and undesirable closeness rating.

Thus, all that was required is to use the information provided by the line balancing (including associated calculations) to bring work stations closer while ensuring that each work station have enough space. Accordingly, a new Assembly layout was formulated (**figure 38**) and presented to the company. In the proposed layout, drums will be trued, balanced at **work centre 1** then passed to **work centre 2.** At **work centre 2** the drum will be added to prepared motors, then the prepared cases before passing the assembled unit to **work centre 3**. At **work centre 3** the various labels will be affixed, the unit tested and data recorded. At **work centre 4**, the packaging foam will be made and passed to **work centre 3**, where it will be used for packaging the unit as required.

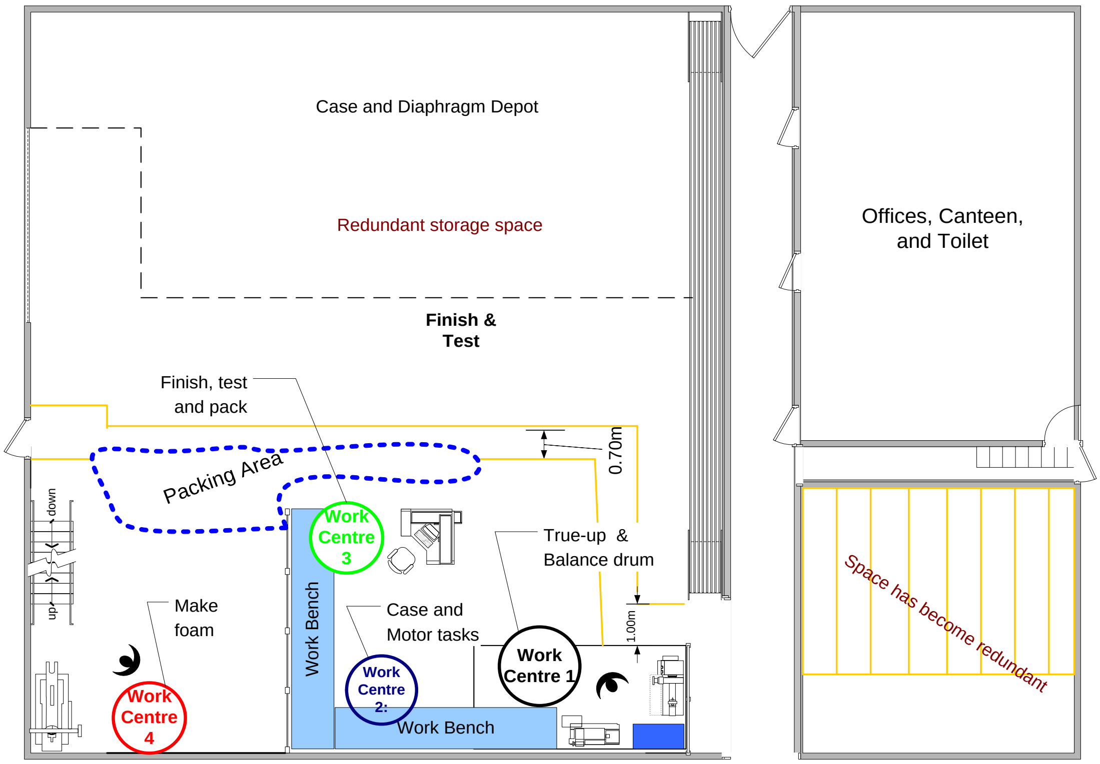

Figure 36: Proposed Assembly Line layout

The proposed layout promises considerable gain space saving, time saving and reduction in component travel i.e. enhanced overall workflow. Presently, when drums and cases are brought back from the powder coaters, they are first delivered to Assembly who then deliver the drums to Manufacturing (a distance of more than 100 metres). At manufacturing department, the drums are trued-up at the Hand spinning workstation and then transported back to Assembly. Obviously, this involves a lot of

waste i.e. waste of excessive transportation, of excessive movement and waiting. Hence, performing true-up operation at the Assembly will result in many improvements including space utilisation. Also it would further increase the capacity of Hand spinning workstation (manufacturing), which is still a bottleneck.
As can also be seen, the space formerly dedicated for the balancing station as well as the space formerly devoted for storing in-process subassemblies such as Cases and Diaphragms have become redundant. Two reasons are responsible for this: first, through actual measurement of space requirement (which cannot be shown here due to confidentiality) it was found that the trueing-up machine and the balancing machine can be relocated to Work centre 1 (it normally houses the testing machine); secondly, due to introduction of small batch method, the company no longer require a lot of space for storing in-process-subassemblies.

The author also suggested investing in machines that can automatically affix the various labels as well as other means of preparing documentation, testing and recording unit's data into the system. This can include bar-coding and barcode reading machine as well as radio frequency identification (RFID) tag technology, which are widely available in the market. This would save assembly time as well as removal of human error when recording unit information into the system.

6.5 Results

This proposed Assembly layout was presented to the company's management who accepted the logic behind it and are now set to implement it. The company have now acquired a reconditioned hand lathe for trueing-up operation. Hence, in the proposed Assembly layout, Truing-up will be performed on Assembly shopfloor close to where it is really needed.

Other results include:

1. Availability of information for planning production in future.
2. Formalising the Assembly layout and identifying free space.

3. Improvement of Assembly quality, tidiness as well as health and safety due to properly marked out layout and implementation of standard Assembly steps.
4. Determination of accurate manpower requirement. For example, it is now clear that the company do not require more than 4 assembly operatives to achieve the weekly output.
5. As confirmed by the Quality Consultant and the MD, the introduction of assembly manuals and associated quality checks has removed assembly errors such as incorrect torqueing completely.

6.6 Conclusion

The ease with which the methodology used on the manufacturing shopfloor was deployed on the Assembly shopfloor further validated the approach adopted by this study. It demonstrated the role power plays when change is being implemented in an organisation (*power is politics' contiguous neighbour*). At the assembly shopfloor, the Operations Director has absolute control and his words are not challenged, and cannot easily be challenged due to existing power balance. Recall that previously the case study company mainly assembled its products. Thus it has considerable knowledge and expertise in this area.

The assembly process was uncomplicated; the operatives did not own any special skills unlike the operatives on the manufacturing shopfloor. The skills and processes required to work on the assemble shopfloor can be learned within a few hours; as a consequence, use of temporary workers supplied by recruitment agencies was common. The assembly operatives cannot form a cohesive unit and have no bargaining power. Therefore, they cannot strive for job control; optimising their work was easy since all that was required was deployment of manufacturing optimisation tools. There was no need to pay too much attention to the human side unlike the situation met on the Manufacturing shopfloor. Deploying WCM tools may have their attraction because of their precise analysable characteristics but Politics is a fundamental part of all organizations – large or small, manufacturing or otherwise.

And although political issues by and large are not always easy to decode, knowledge of it should belong in the toolbox of academics and those wishing to implement process improvement particularly in SMEs.

Chapter 7
Discussion

The objective of this thesis was to gain insight into how to evaluate and assist SMEs to become cost effective within their business. Towards this ends, this thesis reviewed academic theories on optimisation of manufacturing techniques and methods of process improvement as found in literature and discussed their relevance to SMEs. Using a case study company, as an implementation and validation platform, a conceptual framework was developed which SMEs can use to achieve the most out of their existing and usually scant resources in order to become more competitive. The findings are put in three of the case study company's contexts namely the business process, the manufacturing shopfloor, and the assembly shopfloor.

The results and findings confirmed the need for conceptual framework introduced in this study. The work demonstrated that the human side of process improvement is equally if not more important than the deployment of the World Class Manufacturing (WCM) tools and that the key to this is sensitivity to local sensibilities via the Political Approach. This recognises the role of power and politics in manufacturing environment such as in the case study company studied in this thesis.

In what follows, this chapter will discuss the result of the research presented in this thesis and consider their implications as well as any inferences along with analysis of new themes thrown up by the research. The discussion is presented under different headings to highlight chronological achievement of work carried out in this thesis.

7.1 Process improvement in literature

The study started by tracing the history and evolution of manufacturing process improvement. It was shown that although the methodology advocated by Scientific Management such as division of labour, job analysis and timing can actually improve productivity, one must however be careful as to how far to take it.

A machine-like organisation where people are simply cogs carrying out their carefully prescribed task, using their prescribed authority, to achieve carefully worked out organisation goals of efficiency and profits were shown to be too simplistic. Efficient production methods need to be balanced with peoples' need for belonging, security and satisfaction in their job. Hence, enlarging jobs and empowering people to continuously improve their process should ameliorate scientific management methods as demonstrated by the successes enjoyed by the Human Relationship and Behaviourists' Movement. On the other hand, it emerged that the panacea does not lie in Human Relationship and Behaviourists' movement job enlargement/empowerment alone as have been demonstrated by problems experienced by Swedish companies. More recently, emphasis has shifted to World Class Manufacturing (WCM) methods such as Six Sigma, Lean, Lean-Six Sigma, MRP, MRPII, SPC, TOC, FMS, and CIM amongst others.

Japanese inspired Lean Manufacturing is now almost synonymous to WCM; perhaps explained by the fact that in today's business environment, the success of manufacturing companies hangs to a large extent on its chief tenets. For examples, compressing order-to-delivery time, just in time delivery of materials and elimination of all forms of wastes such as unnecessary movement, defects, overproduction, etc. using tools such as one-piece flow, Kanban, single minute exchange of die (SMED), etc. It is apparent that a company that manufactures low priced, quality products produced at a lower cost and delivered faster than the competition is likely to emerge as the more competitive.

To buttress this point, there are a large body of evidence in literature to prove success and advantages of Lean techniques - *see for examples* Womack and Jones's The Machine that Changed the World (Womack *et al.*, 1990), Lean Thinking (Womack and Jones, 1996) and the case study of flow manufacturing implementation at ACME narrated by Motwani and Mohamed (Motwani and Mohamed, 2002).

As was the case with the Human Relationship and Behaviourists' Movement, simple application of Lean techniques alone are also not the solution; in fact blindly copying the Japanese system of Kanban, etc. have been shown to be counterproductive.

Operational effectiveness and good strategy must complement each other and are both essential ingredients for superior business performance.

Taiich Ohno and Shigeo Shingo took up to 30 years to develop and implement Lean Manufacturing at Toyota. The Lean tools are an assembly of solutions that they implemented and refined over 30 years period as a response to their company’s requirement to draw materials just in time and to deliver products to the customer as and when required, hence the word (just in time). Ohno and Shingo were not looking for one size fits all solution to every manufacturing problem. They just wanted to solve Toyota’s problem. Reducing stock, driving down cost, just in time and reduction of lead times, and using less space makes sense. These are what every company desire and are achievable using Lean Manufacturing tools. Hence companies can certainly improve their processes using these broad based solutions but should remember that they may not necessarily apply in every situation. There are many reasons why this cautious stand is valid. One reason being the culture-dependence of the Japanese manufacturing successes; Japanese companies have not always duplicated the same success in their companies located outside of Japan. Moreover, Lean Manufacturing requires significant changes to production processes, and employee training as well as resource commitment. The operating conditions, environment, history and resource availability to companies differ; thus what is implemented and how it is implemented is bound to differ as well.

7.2 SMEs and a framework for achieving process improvement

It was mentioned in the previous section that simple application of Lean Manufacturing techniques alone may not be enough for an optimal solution and also the nature of a company is too often different, which indicates that what works for a large company may not work for an SME. A large number of successful implementation of WCM tools reported in literature is about large companies. SMEs and large companies differ in many respects especially in terms of resource availability, knowledge, personnel, enabling culture and willingness to adopt change.

As demonstrated within the literature review, although it is often taken for granted that change will be easier in smaller companies because fewer people are involved and decision-making lies with the owner-managers, this was not the case in the case study company studied in this thesis because neither change nor communication was found to be easy or better; and the culture was also not unified. Thus, neither verbatim copying of the operational tactics of Lean Manufacturing nor the examples of large companies is suitable for the case study company. Neither should this be assumed to be the case for every SME; one size cannot fit all. And even among the SMEs, there are dissimilarities. This is why many practitioners prefer studying an organisation's unique environment before matching particular WCM tools to the SME as demonstrated by Lee and Chua's (Lee and Chuah, 2001) SUPER methodology.

The case study company is in the envious position of having good products, which are selling well and only embarked on the project as a proactive step to enable it become even more competitive. At first glance, the problems of the case study company would appear to a casual observer as simply a question of implementing Lean Manufacturing and other Operations Management tools. This is until one becomes aware of the manufacturing history of the company as well as the particular issue of divided culture existing within it. This then demanded the question: what is the correct framework for achieving process improvement in an SME such as the case study company with limited manufacturing experience and resources? There is a paucity of such frameworks and what was found were unsuitable. This lead to the development of the framework presented earlier. The framework recognised the great importance of operational tactics but pointed out that at its heart there should be a strategy that is sensitive to local sensibilities (e.g. organisation goals, oftentimes heterogeneous goals of the various organisation members, the ethos of owner-managers, company culture, norms, etc.) and consequently the importance of politics within a company.

7.2.1 The Political Approach

Although it is not often talked about, the politics has maintained a constant presence in the organisations. The use of politics and power in organisations is rife. This can in part be explained by the fact that organisation members do not work only to satisfy organisation goals; people go to work with various and often, conflicting expectations. Thus, use of power and politics becomes inevitable as they compete over scarce resources, influence, control, etc. Most people who have ever worked in a company can tell from personal experience, hunches or anecdotal evidence that behaviours in organizations are frequently political in nature. For examples, systematic soldiering and the fibs that factory production workers use to gain time on the job is well-documented and common knowledge. When time available is higher than available work, the work is "stretched" in order to make use of all the available time. One reason for this is a valid fear of losing income or redundancy. The author was once told how overtime work could be secured - all that is required is to complain about machine malfunction to the maintenance team just before break time. Hence, not only was longer break time secured but by the time a group of cooperating colleagues do this over three shifts, tardy lead time will loom, which will in turn force management to appeal for overtime work "volunteers".

Sometimes it can be a simple case of people at the bottom of the hierarchy without much formal authority seeking to exercise what little power they have to control the amount of work management can impose on them. A new operative is usually told right at the beginning what the "numbers" (quantity per hour) are for a particular task by the longer serving colleagues. It is a very brave and possibly foolish operative who will dare to "burst" (break) a rate set by a group of work colleagues. That operative will soon find out that his or her position has become untenable. Conformance can be obtained via many means – teasing (being called a scab), isolation, threats and sabotage. The author have heard stories of hammers belonging to an offending operative being welded to his work bench, his tools, jigs and radio going missing, and his welding machine setting disarranged.

Faced with these types of problem, what should a company do to improve itself and limit the damages? Should it resort to motivation theories, issuing orders, or simply implement World Class tools of Lean Manufacturing? It is clear that "*in the harsh realities of company, life is better sometimes to be able to fight fire with fire if, in the long term, you are able to demonstrate organisation benefit, rather than pursue naïve* *truth, trust, love and collaborative approach which delivers nothing but de-motivation and cynicism* (Butcher and Clarke, 1999)". Knowledge of politics, political motives and their manifestation can be an effective tool. Unfortunately, the study of organisation politics has not become very fashionable in academic literature of manufacturing process improvement. Politics is often equated to underhand tactics such as deception, and other unethical behaviours. But while unethical behaviours can be an important component of organisation politics, organisation politics is a much bigger concept. Politics can be negative but not necessarily. It is important to understand the role politics play in organisation life. One then need to know sources of power and which power source to call upon when resistance is inevitably encountered. Resistance is a natural response to change because change often challenge comfort zones and may have the added disadvantages of militating against vested interests and carefully cultivated power and influence. A person or a group can successfully deploy resistance if the balance of power is one-sided in favour of the resistor/s. But this can be dysfunctional as short-term goals are pursued by the sectional interest to the detriment of the legitimate interest of the organisation. To control this, knowledge of politics is a requirement.

As stated earlier, the natural state of most organisations is dynamic equilibrium, which is characterised by conflicts due to incompatibilities between the various organisation members, and political activities characterised by antagonism and compromise. Thus, where an actor or a group of actors want to effect a change, the actor(s) must possess more power; without the ability to influence change, change cannot occur. Therefore power is central to deciding the outcomes of a change project such as in this study; hence the reason for introducing the political approach described in this thesis.

Political behaviour pervades the human organisation; consequently even though the study made full use of the operational tools of Lean Manufacturing, the tools were used within the context of the Political Approach. Unlike much of the earlier work on process improvement, this study differed by recognising the importance of the political approach combined with the use of WCM tools and followed Deming's suggestion to avoid neglecting the psychology, which compels the humans that make up an organisation's system. The experiences of this study suggest that paying attention to the human side of process improvement is very essential. An organisation does not stand on its own; it is usually created and peopled by human beings. Therefore, to change the organisation one must start with changing the people within that organisation. But human beings just like other dynamic homeostatic systems cannot be manipulated in the same way as machines or inanimate can. Neither can change be simply ordered by those with legitimate authority since authority is not synonymous to power or influence even though they often coexist.

7.3 Business Process Examination

Manufacturing and Assembly sections of the company comprised the main areas where the work of this study was needed and carried out. However, it was recognised very early in the study that the manufacturing function alone cannot make a company successful and that efficiency needs to be approached in a holistic manner.

Hence, the study started by first examining the case study company's overall business process. This included examination of the company's current procedures and systems, documentation, performance level with regards to quoted delivery times especially manufacturing/assembly times in relation to quoted delivery times, how non-standard orders are handled, purchasing department procedures, how the company handle unit and spares order combination, how the various departments liaise and exchange information. That way, it was possible to highlight improvement opportunities as well as clearer understanding of what everyone needs to be doing.

The findings of the study were based on interviews of selected participants and analysis of the company's workflow procedure. The participants offered insight and made comments that underscore the tension that exists in their roles as well as in their departments, which helped to establish and highlight problem domains facing the company. Ostensibly, what emerged are problems caused by poor training, lack of formal procedures guiding the activities of the organisation members, which is compounded by poor communication. However, a closer look and reading in between the line at some of these observations and comments yielded glimpses that can be explained using the political approached introduced in this study.

Kacmar and Ferris (Kacmar and Ferris, 1993) have this to say: "*Organisations make it easier for employees to engage in political behaviour by providing few rules and policies for guidance. In the absence of specific rules to prescribe how to act, political activity will be more likely to occur. Circumstances in which few rules exist or the rules have not been clearly communicated are ambiguous. Ambiguous circumstances allow individuals to define a situation to fit their own needs and desires. This redefinition of the situation is often considered political behaviour"*.

Thus, conflicts and use of political behaviour often occur due to limited resources and the ensuing competition over these resources. The situation becomes worse if there were no clear procedures for allocating and sharing the scarce resources. For example, it appears that Purchasing duties are not clearly defined; presently their function cuts across most departments and meander into functions such as scheduling. One of the major complaints highlighted by the study includes how the Export Sales department are given priority over everybody; "everything stops for containers to go out or for large export orders". It should be noted that resources include not only size of departmental budget but perceived power and the ability to commandeer manpower, as Export Sales has been able to do. Another complaint include how Export Sales department complicate over-stocking and double ordering by not "understanding" how to use the company's SOP system to delete works orders.

Inter and intra departmental communication in the company was neither excellent nor open even though the company's employees deemed cross-functional communication very important. This was blamed on the senior management; the size of the company mandates that the Directors are inevitably involved in both operational and strategic decision making. Consequently, simple issues were not being resolved efficiently, and affected parties are not consulted thus causing knock-on effects down the process line. Furthermore, no one knew who was in charge of whom and which department is responsible for what processes. A high degree of interdependence exists between the company's departments. Thus, where any of the interdependent departments does not provide the other with clear and sufficient information, poor performance will follow. When communication is poor or ambiguous, Chinese-whispers, gossips, rumours and clichés will be used to fill its place.

Following the investigation and analysis, it became evident that apart from new layout, machinery, improvement to computer system or training on how to get the best out of existing one, what was required were creation of unambiguous policies and procedures to define relationships, handoff deliveries, appropriate behaviors, and line of authority. It was suggested that a cross-functional team be instituted in order to create better and open communication as well as to decide how the company's shared and scarce resources can be better allocated. The company implemented these recommendations as well as those suggested by the resulting cross-functional team and reaped the benefits described earlier in chapter 4. The more cross-functional communication the company can generate the higher the likelihood of reducing any negative impact of office politics. As a company grows it needs to put systems and controls in place. Without these systems and controls in form of rules coupled with poor communication, people define their own situation to fit their own needs. When this happens, negative and unproductive political behaviors become very likely.

What became even clearer is that it is necessary to put the human side of an organisation in order, before seeking to improve the technical side. Furthermore, it can been seen from the issues thrown out by the investigation, that improving the manufacturing processes without first ensuring that the supporting business processes is likely to be counterproductive; it can for instance lead to the problems of sub-optimisation. The ideas behind sub-optimisation emphasis that independently optimising the outcome or goals of a system's subunit (or subsystem) will not optimise the system to the optimum but may in fact worsen the system's effectiveness i.e. "tragedy of the commons" since the whole does not always or necessarily equal to the sum of the parts. Starting with the company's overall business process allowed the study to understand how improvements to each subunit are likely to affect the overall system. It also gave the author the opportunity to gauge local sensibilities and identify internal politics that eventually lead to the approach used by the study.

7.4 On the Manufacturing and Assembly Shopfloor

The work done in these areas comprised the critical work performed by the research study for the company and provided the validation for the conceptual framework (figures 3) developed by this study as well as the Political Approach. Right at the very beginning, the operatives on the manufacturing shopfloor displayed a high degree of antagonism towards the process improvement project and towards the author. Rational bureaucratic models and simply applying the tools of process improvement were clearly insufficient to deal with the case study company's manufacturing problems.

An investigation into the background of the operatives revealed that they have worked together for a very long time and have become not only a cohesive-in-group but almost tribal. Through several informal discussions with them and the stories[14] they told about their experiences working at first for a former employer before being acquired by the case study company provided an explanation for their cohesiveness.

Resistance is a natural reaction to change especially when that change impinges or challenges a valued resource, position or power, means expending effort, there is disagreement about which change to implement, who should implement that change, and the timing of it.

It should be recalled that the aim of the project on which this study is based helped the company reduce its operating costs, increase capacity and output and make the company more competitive. Recall also that the identified technical means towards this ends include full review of the case study manufacturing processes, workflow plans for each product, recommendations for capital equipment upgrade, development of standard times to help with accurate product costing, formalisation of the production process layout, multi-skilling of the operatives and reduction of lead times. Identifying and applying appropriate tools of process improvements such as those used in Lean Manufacturing can easily achieve all of these. However, implementing

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[14] Not revealed here due to confidentiality

these tools involve significant changes to the way the manufacturing operatives operate and certainly threaten established power relationships. Thus, conflicts and resistance encountered in this study can be explained as a case of vested power fighting aspirant power from changing the status quo. Change happens if spirant power defeat vested power or if old and new powers are synthesized into a new form of power relationship. Those who wish to bring change to an organisation must reckon with opposition from those currently benefiting from the system. Such oppositions can take all forms and can easily degenerate into negative political behaviours such as sabotage and skulduggery. The ability of one party to gain the upper hand depends on how much power the party can call upon. Hence power is very important to understanding and dealing with resistance. Pfeffer described politics as the "study of power in action" (Pfeffer, 1981b). Consequently, knowledge of organization politics should be in the munitions store of those wishing to implement process improvement.

With the above points in mind, the sources of power available to the operatives were analysed using a number of heuristics tools such as Actor/Issue matrix, Relationship matrix, Ends/Means matrix, Stakeholder analysis and Force-Field analysis. It became clear that power available to the operatives stem from their ability to act in concert and to exert the effort required to resist legitimate authority of the company. A whole workforce producing an organisation's product, which is its raison d'être cannot be sacked en masse without harming the company. Besides, such group of operatives have several means of attaining their goals. Mintzberg noted that operators can resist bureaucratic control simply by "working to rule" (Mintzberg, 1983). In essence they applied the bureaucratic rules so rigorously to such an extent that the organisation can no longer function.

As per the case study company, the operatives also have specialist skills as well as product specific knowledge precious to the company and they have been able to shroud these skills with a myth of scarcity. The company depends on them. These gave them a lot of power and the improvement project was seen as a threat.

Cases of both unskilled and professional operators exercising group power and imposing their goals on organisations are recognised in literature. Crozier narrated the case of how in tobacco factories; maintenance engineers thwarted both production workers and supervisors from performing machine maintenance:

The unforgivable sin of a machine operator is to “fool around” with her machine. Maintenance and repairs problems must be kept secret. No explanation is ever given. Production workers keep their skill as a rule-of-thumb skill. They completely disregard all blueprints and maintenance directions, and have been able to make them disappear from the plants. They believe in individual settings exclusively, and they are the only ones to know these settings… these practices are necessary for preserving the group’s absolute control over machine stoppages (Crozier, 1964).

The maintenance engineers were powerful because they were able to control uncertainties facing the companies (i.e. the breakdown of necessary machines). On top of that, their capacity to cope with this uncertainty cannot be easily replaced. Power that comes from owning specialised knowledge can decline very fast if others can gain access to such knowledge. Monopoly of such knowledge gives inordinate power; consequently organisation members do everything they can to gain access to this knowledge. For example, owners and managers see in it a threat to their authority/legitimate power; they try to thwart it by reducing and breaking the skill into easily learnable steps (as in manuals and operation instructions) so that others can easily master the skill.

On the other hand those with the expert power do everything they can to keep their skills and expertise secret. In the case of the maintenance engineers cited above, this can include the practice of training new engineers verbally, and “disappearing” documentations that would have made the training of new employees easier.

Similar to Crozier, Pettigrew (Pettigrew, 1973) described the struggles between computer programmers and a manager of the Systems Analysis department in which the programmers have considerable expert power between 1957 and 1961 because of their ability to deal with uncertainty when implementing new and essential computer systems. Using their expert knowledge, the programmers attained high status, salaries, and the impunity to flaunt bureaucratic rules and display arrogance. As a result, they were resented by other organisation members. As quoted by the aforementioned manager of the System Analysis department in the said paper by Pettigrew, (*see Pettigrew, 1973 in pages 98-99*) “they were a little in-group. They lark around at Wolverhampton like a bunch of school kids. I thought I must get control of them.” Continuing, Pettigrew (Pettigrew, 1973) said that the manager was fortunate because soon between 1962 and 1967 system analysis expertise began to challenge programming expertise. Sensing the threat and erosion of their power base, the programmers took to tactics similar to that of the maintenance engineers narrated (as described by Crozier). For examples, they created protective myths about their knowledge as well as norms of secrecy, control over training and recruitment. However, according to Crozier, “as soon as a field is well covered, as soon the first intuitions and innovations can be translated into rules and programs the expert power disappears”, (Crozier, 1964). Thus, the manager was able to thwart the programmers’ tactics by substituting their expertise; other programmers were brought in. And he got the programs written. Finally, the manager had the programmers moved physically to detach them from their power base.

Based on the above case study by Pettigrew, and supported by Crozier (Crozier, 1964), it can be inferred that people who have expert power often use the tactics of not writing down information as well as use of specialised language and symbols to make it difficult for others to understand and undermine their expertise. In support of this argument, Pfeffer (Pfeffer, 1981b) noted that the various professions have been particularly successful in using specialised phrases and even foreign languages (such as Latin) to make their knowledge less obtainable by one not well-schooled in the profession. He gave the example of MBA’s in finance talking about alphas and betas and concluded that jargon both facilitates communication within the field but also makes the knowledge being communicated appear to be more substantial and more difficult than it really is (Pfeffer, 1981b).

The case study company had no written and formal procedure for the manufacturing and assembly operations. Also, during the study period three production workers were briefly recruited into the manufacturing section but did not last very long. Whether these were intentional action or not by the established operatives cannot be ascertained. But given Pettigrew and Crozier above, it can be inferred that informal procedure favoured the manufacturing operatives' ability to resist. Also, a tight-knit group such as this where each individual has learned what to expect from his colleague sufficient order comes easily, potential for social disruption is low but a stranger presents a problem. Thus, a new employee will find it hard to be accepted into the group and an unwelcome operative cannot endure long.

Mintzberg articulated the tactics for resisting authority and those for thwarting them as games. Such games include insurgency games (games for resisting authority such as in the maintenance engineers above), counter insurgency (games for countering resistance to authority such as by the system analysis manager above) and games to build power bases e.g. sponsorship game, alliance-building game, empire-building game, expertise game, etc. (Mintzberg, 1983). These sorts of games go on all the time; citing Scheff's study of successful resistance by six hundred attendants to stalemate a program of reform by administrators in a mental health hospital (Scheff, 1961), Mintzberg noted that those organisation actors who are unwilling to use political means of influence and prefer to rely only on legitimate power may lose the game (Mintzberg, 1983). It is necessary not to rely on formal control alone to the detriment of the informal control system, which supports organisation changes. Ostensibly, the physicians held formal authority and ought to be powerful but the attendants are a cohesive group that did not break rank and have a whole array of sanctioning techniques such as withholding information, and creating events that deluge the physicians with work. They controlled the options and the physicians have no choice other than to reach a tacit agreement i.e. continuation of much of the old ways in exchange for cooperation.

After identifying the power sources available to the company's manufacturing operatives, and the strategies and tactics for their use, devising the counter measures became possible. The author had management support as well as the expert knowledge of the company's production processes. This knowledge was used to debunk the myth of scarcity (i.e. of their knowledge) and reduced the condition of dependence they created. With his expert knowledge, the author could also present to the board of the case study company as and when was needed the logical reasons, facts, and data to influence the events. Power is best used when it is used subtly. Thus, the author used consultations, negotiations as well as appeal to emotion, sensitivity, and interpersonal influencing tactics such as managing constructive relationship with all stakeholders, developing alliances, using the technique of two step leverage, anticipating the response of individuals to events to obtain goal congruency. Deciding on the timing of bringing in the various process improvement tools, such that any opposition will be unprepared was another tactics used. Coercion was avoided.

The above actions then made it possible to deploy the operational tactics of modern process improvement listed below:

- Workflow study
- Measuring process performance
- Highlight improvement opportunities and implement them (line balancing, identification and amelioration of bottleneck operation, improvement to grub-screw fastening and the push to develop a multi-skilled workforce on the shopfloor)
- Implementation of single minute exchange of die (SMED)
- Introduction of small batch production method
- Improved plant layout and material handling
- Creation and introduction of spread sheet based material planning and requirement sequencing
- Re-examination production process and identification of improved metal spinning method
- Justification for recruiting an extra manufacturing operative
- Optimisation of Assembly

It should be noted that the timing, sequencing and introduction of these operational tactics were deployed within the context of being sensitive to local sensibilities (i.e.

adopting the political approach), which are elaborated on the next sections discussed next.

7.4.1 Knowledge Capturing and incrementally implementing short-term wins

As already explained, the operatives own the skills and knowledge required for manufacturing the company's main products. These skills are of informal nature and unwritten. Thus, it was necessary to capture this knowledge for two reasons. First, informal knowledge not owned by a company is not very useful for that company since the knowledge possessor can leave the company. Secondly, if the company's processes are to be improved, it is imperative to know what those processes are and what is involved. In doing this, the study followed the normal Lean as well as Manufacturing and Operations Management techniques. This involved work measurement, identification of those factors limiting production such as bottleneck and waste activities (non-value added operations) and then determining ways of eliminating them. Where, the study differed from common approach is the choice of tools and timing of their deployment. For example, where Lean practitioners would have used value stream mapping to visualise and analyse the flow of materials and information, in this study spaghetti mapping and process charting were used. Value Stream mapping have many advantages but was found to be unsuitable in this instance. It is hard to use Value Stream Map to map multiple products that do not follow the same routing and it often fail to acknowledge the relationship of the layout of the plant and material handling to process and equipment limitations. Thus Value Stream mapping is biased towards high volume and low variety assembly-like manufacturing environment where processes do not share common resources or equipment. Added to this was the fact that only the operatives knew what steps are involved in the manufacture of the products and there were still disagreement whether their work should be measured and what can be measured.

The capturing of the process flow and its visualisation set the stage for measuring process performance. Understanding operation duration is central to reducing the company's lead-time and efficiency improvement. This called for measuring operation time for each operation and led to serious conflicts about the whole project; it further highlighted the role power and politics can play in an organisation. The operatives simply refused to be timed especially with stopwatch and there was nothing anybody could realistically do about it. This is nothing strange or new and the case study company was not unique in this respect. Control over work and hence the issue of power is ever present in the work situation. Writing in his book "Working for Ford", Huw Beynon noted that most workers *endure* supervision while they are at work and that many of them resent it and have built up defences against it (Beynon, 1973). Hence, "on the shopfloor of many factories the division between the supervisor and the men can be characterised as a 'frontier of control' – management's rights on the one side and those of workers on the other. Illustrating further, he recounted a court case first described by Carter Goodrich in the 1920s. Asked whether a particular miner did his job properly, the over-man (overseer) replied that he never see the man work even though he visited the working men twice a day as the rule stipulated. "…They always stop work when they see an over-man coming, and sit down till he's gone… they won't let anybody watch them"(Goodrich, 1920).

Shopfloor operatives use every available means including but not exclusively 'sit-downs' to assert a degree of control within their workplace. It can for example include using ingenious ways to restrict output or outright sabotage. This is especially effective at a time when a company is experiencing a boom and therefore need to expand output. Such a company needs its workers and cannot really afford disruption. With the case study company, the operatives are especially in advantageous position as already noted; they hold and own the skills required to make the company's product. Consequently, the issue of work measurement (timing) and control in this study became a negotiating situation involving a powerful opponent; it is wise to respect the right of a powerful opponent in a negotiating situation. In negotiations, use of power becomes unavoidable and where power is present there will also be politics.

The average operative who is afraid of work timing often have genuine reasons. Those who measure work are often not those who must perform that work. Often the measurer do not understand that what took an average person 2 minutes to perform in the morning may take longer at 3 am in the morning and that it is difficult for human beings to consistently perform at the same level night and day just like a machine. A common complaint by operatives on the shopfloor is “they think we are numbers and treat us like machines and materials”. It is also the case that those in management position will happily support work measurement for those at the bottom of the factory hierarchy but will reject their own work being minutely monitored and measured. But operatives are human beings who share the same innate desire to seek autonomy to control their own affairs. Yet if the manufacturing operations are going to be optimised and improved, it is necessary to know the task times.

Therefore, given above reasons an alternative to stopwatch was sought. Job cards proved the right tool in this case. It was presented to the operatives as the lesser evil of the two alternatives and they accepted it. It allows the study to measure work and at the same time allow the operatives to maintain a degree of control. The operatives record how long they dwelled on a task; thus they are free to record 10 minutes for a job that took them 5 minutes if they so wished. It should be noted that while it might seem at first like the operatives can cheat if they wished, they couldn’t really do so. The data collection went on for more than 12 months thus any wrong information is easily averaged out. Also it is hard to say that fastening a grub screw took you 10 minutes when in fact it took less than a minute. Some lies can be so blatant that no sensible person can hope to tell it and get away with it. The processes were broken down into minute tasks and it was not really possible to record false task times.

As can be recalled the attempt to organise the accumulated task times using Excel spread sheet later revealed a problem that became an advantage – all the tasks required to manufacture the products have no standard number or formal name. The operatives were seemingly cooperating by filling and returning the job cards. However, the individual tasks are called different names by different operatives and sometimes a different name by the same operative on a different day. For example a task name that started off as “Tack and Weld” on Monday changed to “Jig Up, Put Together and complete” by Friday. It cannot be confirmed whether this was intentional, nevertheless, the result was confusion when it came to sorting and analysing the gathered data. This underscored three very important lessons:

1. The need to understand your processes thoroughly
2. Informal procedure is bad for a company
3. Standardised procedure is the beginning of wisdom

Thus, it became necessary to standardise and formalise the operations and finally gave the company the steps which it needs to manufacture its products in a written form.

With the processes mapped and the average activity times captured, it was relatively easy to calculate that the company should not be struggling to produce 130 units per week if they operate 39 hours a week. In fact, the company could be producing between 180 and 200 units per week provided the operatives work to easily achievable cycle times. Presented with the proofs, the operatives agreed with this argument since the calculations are arrived at using their own recorded figures not ones obtained by a stopwatch. This further validates the use of job card instead of stopwatch; also, the man who has worked on a task over many years must have discovered the easy way and the hard way to do that task. So even if it was possible to force them to allow the use of a stopwatch, they can easily revert to working the harder way and deceive the stopwatch using work measurer.

In addition to discovering unknown capacity it further became easy using flow diagrams to underpin those short-term improvements or Kaizan activities that can be performed to inject life into the project. For examples, Hand Spinning workstation, which was a bottleneck, was retrofitted and the grub-screw fastening operation was improved with very good results. Incremental short-term wins have many advantages; the achieved improvements make it hard for resisters to continue blocking change and it is a boost to morale. It is also similar to the envelopment tactics used by the military – make the opponent vulnerable using a few well-timed blows from several directions. Success of the short-term improvements set up the stage for introducing Small Lot production. Small Batch production was particularly a vexing issue, first because the management was unsure how that would work in their company's environment. Secondly, the operatives were against it. They were against it because it involves a lot of changes in the way the shopfloor operatives have always done things. The author suggested the technique of 5S for reorganisation of shopfloor layout but it was rejected by the shopfloor operatives on the basis that to them 5S is "another newfangled Japanese jargon”. Implementation of Single Minute exchange of Die (SMED) was also proposed to be carried out before the Small Lot production could be deployed.

The case study company’s usual practice was to produce one component at a time without regard to the sequence and quantity that final Assembly required them. This was easy for the operatives because it involved less machine setups and material handling; moreover they have always done it that way. But, it also meant that they usually have about 600 half-finished subassemblies clogging up both the Manufacturing and Assembly shopfloor. It was common for Assembly to have Cases or S3s but without the S1s to finish the assembly. Unsurprisingly, the company experienced long lead times and lack of shopfloor space.

As mentioned before, introduction of the Small Lot had to be negotiated with cognisance of the local sensibilities. Good housekeeping and formalisation of the plant layout were used instead of 5S, and only a modified SMED was deployed. Kanban was not used. When Single Minute Exchange of Die was initially mentioned, the operatives wondered how it is possible to reduce machine setups down to single figures and strongly indicated that they will not consent to anything that will affect their health and safety. No Western country based company can afford to implement a change where health and safety is an issue. This is a clear case of using the bureaucratic control to defeat the system simply by “working to rule” (Mintzberg, 1983). To overcome concerns over health and safety, an arrangement was made to bring in SMED specialists from Manufacturing Alliance (MAS West Midlands). But when they arrived and explained that their methods include using stopwatch, video monitoring to capture non-value added activities and meetings afterwards to discuss what should be done over a period of weeks they were never asked to come back even though their services were free. The Operations Director described the experience as “going down like a tone of brick”. Thus providing evidence that choice of tools and method of deployment must be done with local sensibility in mind. While the company have the authority and right to use their workforce and machines as they see fit, forcing the operatives to accept SMED would have been counterproductive. They could have “cooperated” and simply let a small mishap to happen to the CNC spinning machine, which no one can prove is sabotage. Production would have stopped, money and time would have been lost, customers would have become angry, this author would have been blamed and the study/project jeopardised. While this is only hypothetical, such incidents are not unknown and there are lessons to be learned there. Huw Beynon narrated how some cohesive Wet Deck workers at a Ford plant used to “sort” out a foreman that has “stepped out of line (Beynon, 1973). They could sand the paint off the style lines, which gives the car body its distinct shape. The foreman could be right on top of them yet could not notice anything due to water streaming everywhere, flailing whirlies and workers constantly moving about. The damage would only become noticeable about 3hours later when the finished body shell emerged with bare metal along the style lines. Such incidents will continue until a wise foreman negotiates and miraculously the quality problem will disappear.

Finally, using the political approach during the implementation of SMED proved to be a very successful strategy. The constant interactions and informal meetings enabled the author to explain the underlying principles and demonstrated that they are not going to lose much job control. Again this is important, it is hard for the unversed to understand the love a skilled man have for his tools and his resentment for those perceived as coming between him and that too/machine. At the end, the operatives helped to come up with the ideas used to reduce setup times. For example, they suggested and helped to develop a production sequence that reduces the need for changeover. The author was able to capture changeover activities and their durations and demonstrated that by eliminating waste activities and separating external (can be done while the machine is running) from internal activities (machine must be stopped) and using fore preparation it would be possible to reduce setup times for PNC K2 S3 Spin from 16 minutes down to 6minutes. Additionally, some jib cranes were installed which made the operatives’ jobs easier and ameliorated a real health and safety concern. They used to change over with ropes attached to a forklift, which was dangerous. While it was not possible to implement every suggested improvement such as replacing the time consuming fasteners with hydraulic clamps, those improvements implemented proved successful. Between 25% and 67% reduction in setup times was achieved; this allowed Small Batch Production to be introduced after working out a production schedule which allowed a mix product every day or week as required by the customer. To all intents and purposes the project's objective were immediately achieved consequently; lead time dropped, space and workflow was maximised, stock carrying costs reduced and even the hitherto doubting operatives acknowledged that the "split batch thingy" is working effectively. Some said they no longer experience boredom. The Small Lot method worked so well that the Operations Director immediately extended it to the Assembly shopfloor, where the results were also very positive.

On the Assembly shopfloor the same methodology used on the Manufacturing shopfloor was deployed but without as much problems. By and large, work was measured; each required step-by-step assembly task was captured together with the average duration. This information was used to perform line balancing calculations (cycle times for a required output rate, and minimum number of workstations) and a balanced assembly line accordingly proposed. A further improvement was the suggestion to purchase a cheap second hand lathe so that Trueing-Up can be performed at Assembly shopfloor to reduce material travel times and double handling. It is worthy of note that the only mild protest and hesitation came only from Manufacturing shopfloor operatives who did not want to lose a task it considered one of its own. But, this was surmounted and the lathe was bought.

The assembly process was simple and the operatives were not a cohesive unit; they did not own any special skills unlike the operatives on the manufacturing shopfloor since the skill required to assemble the products can be learned within a few hours thus use of temporary workers supplied by recruitment agencies was common. This once more demonstrated the role power and politics (its precedent/contiguous neighbour or doppelganger) plays when change is being sought. The Assembly operatives have no bargaining power hence cannot strive for job control; optimising their work was easy since all that was required was deployment of manufacturing optimisation tools. There was no need to pay too much attention to the human side. However, unlike Manufacturing, Assembly experienced a lot more quality problems, which can be explained by the high use of temporary inexperienced and perhaps uncommitted workers who have no reasons to take pride in their work. To reduce this problem, standard assembly manual containing every step-by-step instruction together with quality checks was created, validated and introduced. Overall, optimisation work performed on the Assembly shopfloor showed improvements in form of reduced space requirement, WIP and finished goods reduction, better flow of materials and fewer footprints.

The incremental application of process improvement, optimisation and manufacturing theories in the case study company reached a high mark when the author performed process rethink as suggested by Shingo (Shingo, 1985). This involves making improvement to a process as opposed to improving the operations. And this was one of the reasons for searching for alternative processes for lids to case bodies to welding as performed in the company. It led to identification of the technique of spinning on air and using innovative internally segmented and eccentrically mounted tooling by the author. This discovery completely reduced the value of the roles played by the operatives. It is not too difficult to recruit new CNC machinists, whereas the technique of welding the lids to the case bodies lip to lip cannot be easily acquired. Great skill is demanded and such skills can mainly be acquired via working on the company's products as the operatives have done since many years. Additionally, this spinning technique has many advantages which was already highlighted in this thesis and include for instance, consistent quality, elimination of Lid as a part, reduced lead time and WIP, greater flexibility, passing of knowledge from the operatives to machine, it is possible to eliminate 3 welders from the workforce should the company wish, and much more. A reduction of time associated with 5 processes was potentially identified as19.40 minutes (from 24.40 minutes down to 5 minutes - a cost saving of £4.85 per unit; with total payback time for the implementation of this tooling being estimated at 14 months).

The new spinning method was not implemented immediately due to several considerations but the company now have the information and can deploy the method whenever they wish. The immediate implementation was not the intention of the author; it was amongst other things simply a strategy for shifting the balance of power away from the operatives i.e. via the reduction of the condition of dependence (non-substitutable skills) they imposed on the case study company. It worked completely because thereafter cooperation from the operatives was much easier obtained. For example, the operatives on their own accord suggested to the author how capacity and workflow could be improved further by recruiting a general labourer. At first it appeared as if the case had no merit but analysis indeed showed that they were right. It has many merits, not least the ability to add additional 20 units per week to the overall weekly output. The case was presented to management who accepted it and engaged a labourer.

Clearly, it is equilibrium of power rather than peoples' good nature, which contributes most to harmonious relationship in an organisation.

7.5 Reflection

The action research methodology adopted to achieve aims of the project set out to demonstrate how to evaluate and assist SMEs achieve the most out of existing resources, and hence become more competitive. As can be seen size, lack of resources, knowledge, and appetite for change were found to be some of the issues, which meant that the tools required to implement process improvement had to be tailored to suit a SMEs' unique situation. In the case of the case study company, incremental implementation proved to be the most suitable. The research showed that despite culture change problems, equipment, staff and resources issues if academic theories, various process improvements, optimisation and manufacturing techniques correctly applied could be used to achieve good results.

During the period of this study, weekly capacity rose from about 139 units per week to approximately 240 units (as confirmed by the **case study company's own figure shown in the final project benefit report submitted to the university and the KTP organisation**). This counted for an increase of 72% of production output, which enabled the company to increase sales by 28% and to reduce lead-time from 10 weeks down to 5 weeks (as quoted by the case study company in **the final project benefit report submitted to the university and the KTP**

organisation). The anticipated sales increase of £70,000 shown as the business case for the study was more than achieved with an actual increase in sales of those products affected by the project rising to £868000. Sales turnover rose from £6.305 million to £7.237 million. Profit before tax rose from £1.129 million to £1.767million. £4500 was saved through improved labour efficiency (8% reduction in labour cost as a percentage of unit sales value). Work in progress as well as finished goods inventory was drastically reduced (estimated at 50%). The company estimated that it saved £5000 simply by paying less interest on stockholding as a result of smaller batch production. As a result of the reduced inventories, space requirement also reduced.

Apart from above quantifiable impacts, the study's other chief achievements include capturing what was previously tacit and informal knowledge held by the manufacturing operatives; this was formalised into standard procedures and made the property of the company. Knowledge that is not externalised is not useful to any company given that it is knowledge which, gives a company its core competency hence its competitive advantage.

An immediate by-product of this is the aforementioned completed costing spread sheet, which will enhance the company's ability to monitor and control its manufacturing and assembly costs. Based on the developed operation times the spread sheet was developed to establish an accurate cost analysis for all standard and stainless Units (a total of 9 products). This means that the company is now in a position to make informed business decisions such as cost control, finding variances, efficiency measurement and elimination of inefficiencies. The various costing spread sheets are not displayed due to confidentiality and commercial sensitivity.

The in-house material requirement planning spread sheet, which increased planning speed, removed errors associated with a manual system as well as reliance on product knowledge, was another important accomplishment. The various steps taken as part of the study including shopfloor formal and informal meetings, the initial business process investigation, which investigated and gave advice about cross-functional communication contributed towards the company's cultural integration effort.

It is also worthy of note that the implemented tools are likely to lead to future/further improvements. Asked what further impact is the study expected to have on the company's performance. The Managing Director answered, "Further lowering of labour unit cost per unit, flexibility, shorter lead time, shorter cycle times, better utilisation of resources and increased capacity".

The findings of this research project study has demonstrated that standardisation (to create repetitive, consistent process), process planning as well as through documenting, codifying, externalising knowledge can make significant impact to the overall improvements of a manufacturing company (Agnar *et al.*, 2004; Wong and Aspinwall, 2004a). It has also shown that behavioural aspects of process improvement implementation also require significant attention. Considerable difficulty and skulduggery was experienced during the implementation stage of this study. Power and culture issues were at the heart of the problems.

Even in companies without specific cultural issues, resistance to change is a recognised problem. As noted by Proctor and Doukakis (Proctor and Doukakis, 2003) resistance can emanate from fear of unknown, lack of information, threats to status, fear of failure, and lack of perceived benefits. Their study went on to point out that "people like to feel that they are in control of what is happening to them and the more that change is imposed from the outside by others the more they will see it as something to feel threatened about and the more they will resist it; people resort to using their last remaining power base – their will to co-operate." Many change program fail mainly due to resistance issues (Maurer, 1997). Therefore managing resistance is possibly a more important concern than other change elements (O'Connor, 1993). And while management usually neglect this equally important human aspect, preferring instead to concentrate on the technical side (Levine, 1997; Tessler, 1989) it is crucial to balance the human and organisational needs when implementing major change (Spiker and Lesser, 1995).

The first step taken was to avoid seeing the situation as difficult but as a challenge – an opportunity. Attempt was made to understand how they feel and show them that the reasons why they feel the way they do is understood. This is important as operatives lacked the broader perspective or knowledge base of why the change is required, neither do they share same accountabilities as management. Hence, they questioned how the change would affect them personally. They have a lot of empirical knowledge, painfully acquired through many years of producing the case study company's product. For this reason, respect and deference was shown to them. Acting on a tip off from the Managing Director and Operations Director that the Manufacturing Shopfloor Supervisor is fanatical about Fuchsia flowers, the authors then took an interest and became enthusiastic about Fuchsia flowers. Surprisingly, this opened up communication thus supporting Kotter and Cohen's assertion that appealing to peoples' feeling instead of using figures and facts only is likely to motivate people to change (Kotter and Cohen, 2002).

It is not enough to have good proposals; it is perhaps more important to secure the 'buy-in' from those people who will be directly affected by any proposed change. Respect and being sensitive to local sensibilities, which are at the heart of the conceptual framework developed in this thesis, an abridged version of which is shown as **figure 39**, are the beginning points towards achieving this.

Shingeo Shingo (Shingo, 1988a) narrated how as a young engineer he learnt that people would not always act as you wish even if you got them to see your point. "You have to be able to persuade his or her personality – the rational and the emotion governed" Shingo then advised using the Socratic method which is asking a series of questions that will eventually lead the interlocutor to arrive at the desired conclusion by him or herself.

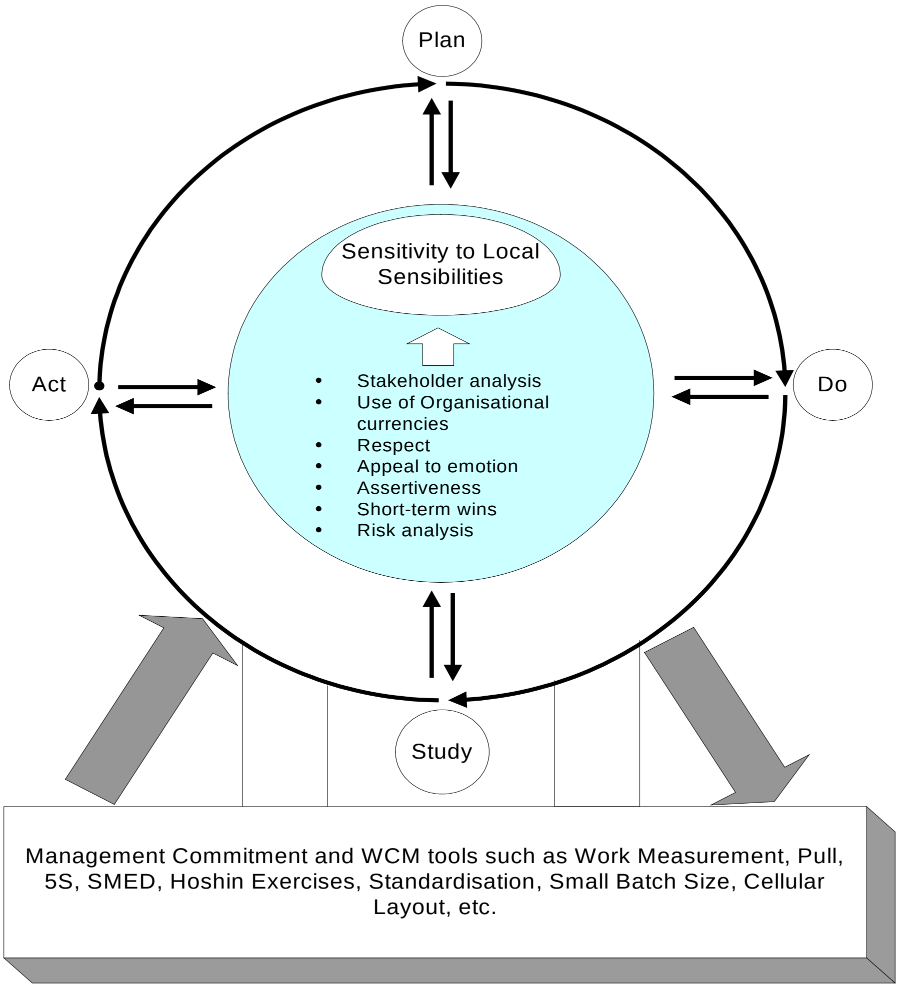

Figure 37: A framework for achieving process improvement in (SMEs) with limited manufacturing experience

When workers as in this case study company resist and try to control work, it is not mainly due to bloody mindedness. They have needs to fulfill just like everyone else (Mintzberg, 1983) – innate psychological need for security and safety. The process improvement implementer need to understand that it is not just fairness that drives efficiency and productivity increase drive, economics and power are the chief drivers. The manufacturing organisation is there to make profit and thrive; it does this by using less to make more (maximizing productivity). This often means asking the workers to work that bit harder or a fair day's job for a fair day's pay. Beynon asked the question, "What is fair, fair for whom?" commenting further, he noted that "maximising returns makes sense only if you're not going to be maximised into the dole queue" (Beynon, 1973). The more a company can achieve with less resources (e.g. people), the less people it will be willing to employ and remunerate. It is not very reasonable to blame a person who have mortgages to pay and perhaps children to feed for looking after own interest.

Even for managers, "...it is difficult to remain polite when the object of the game is control of one another's sphere of influence, or more to the point, of one another" (Mintzberg, 1983). Turkeys do not normally vote for Christmas. It is also worthy to note that those who ask others to work harder often sit in nice offices and drive company cars. They do not have to listen to ear bursting sound of a spinning machine in operation or weld back plates even during 35 degrees centigrade. Nevertheless, a company must make profit otherwise its worker will have no job. A major failure reason amongst manufacturing companies is excessive production costs. Hence, the clever thing the implementer should do is to acknowledge the right of both parties, and sell the idea of working smarter, not harder.

The author also found stakeholder analysis to be a very important tool. It was useful for drawing up how the changes will affect the stakeholders; who is a potential partner, who is passive, who is an opponent/threat, defectors; the power of the group over a member; the negative and positive sanctions that they have at their disposal and how much the individuals value the group. It was this knowledge as well as use of organizational currencies (Cohen and Bradford, 1991), which enabled the author to gain, first the support of one operative then with time that of others. Organisational currencies include sharing harmless but privileged information, giving emotional and personal support, providing tasks and information that gets people noticed, etc. It was also important to be assertive, highly visible, credible as well as quick to respond to suggestions and requests.

The management performed an important role in the study; no job was lost, instead it invested in the wellbeing of the operatives. This helped to improve trust, loyalty and buy-in. Top management commitment is essential for a successful change implementation as are "explicit behavioral change program with specific improvement target, clear reward system, surfacing actual norms of behavior, establishing desired norms, identifying behavioral gaps, closing this gap and sustaining the change (Jabnoun, 2001). This study has shown these to be valid. Even though communication opened up, underlying problems did not disappear completely. Tensions boiled over many times but were dealt with creative win-win negotiation. There were occasions when help has to be sought from the top management; they then made it clear to the operatives why the change process is needed.

Conflicts and quest for control can easily degenerate into negative political behaviours such as lies, deception, and skullduggery. This is confirmed by Huw Beynon who described in his book “Working For Ford” how in the 1960s at the Ford plant at Halewood a gang of workers in their struggles with the foremen resorted to peeling the foreman’s orange, carefully, removing the fruit, and filling the skin with bostic (a substance which sticks and burns). The remoulded orange was returned to the supervisor’s bag, they then gleefully wait and watch him trying to peel it. They also made bostic bombs and threw them into rubbish containers, which resulted in explosions and flames as high as twenty feet (Beynon, 1973).

A friend of the author, Malcolm B, narrated how as a welder in one company a bunch of colleagues who wanted him out filled a plastic bag with acetylene gas (a highly flammable gas) and hid it under his welding table. Serendipity saved him and he had no choice other than to leave the job. A shrewd political operator can turn incidents such as these, despite being nasty to good use. In the same book mentioned (Working for Ford), Huw Beynon narrated how a foreman attempted to plant a component in one of the more troublesome shop steward’s haversack. Luckily, for the steward the foreman was observed. So, forewarned, the steward took plenty of witnesses so that when he was stopped at the gate by security he was not just able to free himself but became “the man they tried to frame but failed”, and consequently became “the man who couldn’t go wrong”(Beynon, 1973). The shop steward won and the foreman lost.

Similarly, the author was once threatened with physical violence during one of the several ugly incidents experienced during the study. This proved to be a turning point in favour of the author just as in the shop steward's above. The alternative would have been escalating the issue, quitting while complaining of resistance and skulduggery. Results must be delivered despite the situation and that is hard to achieve unless that project is politically acceptable. A survey conducted by Butcher and Clarke found that around six months after implementing change, 80% of the managers found that understanding political motives was useful or very useful in managing key decision makers, moreover, their success was dependent on accepting the inevitability of these motives. A whopping 95% saw managing political behaviour as central to the job of managing change (Butcher and Clarke, 1999).

Thus, to summarise the result of this discussion section, the author can based on the findings of the research study and the developed conceptual framework, propose an 11 step roadmap, which the academics and the researchers can use to evaluate how they can assist SMEs in adopting continuous process improvement. The 11 step roadmap suggested by the author reads as follows:

I. Have a vision - Be clear about what the study want to achieve i.e. define what the project is all about.

II. Study and understand the company (the first should be the overall business process i.e. how the organisation does its business), its processes, people, environment, history, goals (which can often turn out to be heterogeneous), norms, etc. Spend a lot of time talking to people both at formal and informal occasions. Spend a lot of time standing on the shopfloor just watching and observing – a clearer picture of the processes flow, problems and improvement opportunities will start to emerge. This will then help you to develop a tentative improvement action plan, which should include time lines and mile stones. In the case of this study it included:

- Full review of manufacturing and assembly process.
- Formalise production process layout.

- Produce workflow plans for each product line.
- Find means to maximise shopfloor space.
- Develop standard times to help develop accurate product costing and highlight improvement opportunities.
- Optimise process flow and sequencing in order to reduce lead time and cost associated with production.
- Conduct skill audit of affected staff, and then provide training in order to inculcate lessons learned.
- Institute regular meetings to increase knowledge sharing
    - Daily shopfloor informal meetings
    - Weekly meetings with top management
    - Monthly meetings with top management and University supervisor
    - Local Management Committee meetings (every three months)
- Etc.

III. Study the politics of the organisation. This includes identifying key stakeholders using for example stakeholder analysis. Stakeholder analysis has the added advantage that it can be used to develop a communication action plan. Who are the principal political actors/groupings? What are the sources of their power and bases? At this point, possible strategies will start to emerge. Think of possible alternatives as well e.g. persuasion, sanctions, negotiation, etc. Think about impacts of various actions. Tools that can be of assistant here include Actor/Issue matrix, Relationship matrix and End/Means matrix.

IV. Use obtained results to develop a Force Field Analysis; this will help to determine whether opposing forces are greater than driving force and consequently help to identify tactics and how to increase any required force. Such tactics can include coercion, manipulation, co-optation, education and communication, negotiation, use of expert power, and use of interpersonal skills to build trust, shared goals or win-win.

V. Capture present situation ("as is" situation i.e. measure) including all required data to identify a base line, which will be used for any future comparison. This will also highlight improvement opportunities such as bottlenecks. Spaghetti Maps, Value Stream Maps (where appropriate), and Process Charts can be useful here. Measurement of times required to perform the various manufacturing activities are essential; ensure that each activity have unique identification (e.g. name and or activity code). Determine method for capturing this essential information e.g. video capturing, stopwatch, job card or route card. In this study, job card was found to be the most suitable. Refer also to II above.

VI. Identify non-value added activities.

VII. Minimise non-value added activities using appropriate tools such as SMED, better plant layout, line balancing, machine upgrades, etc. it is important at this point to implement several "short term wins" because short term wins undermines cynics and change resisters, makes the intended results visible for all to see and hence makes it harder for any naysayer to block the needed change. In this study, Hand Lathe Workstation was for example retrofitted, grub-screw fastening operation was improved and some jib cranes commissioned. Also, small batch method of production was introduced and a spread sheet based MRP to automate material scheduling was developed leading to a reduction in shopfloor space, lead-time, and manufacturing costs. This section should be done incrementally and not at once.

VIII. Study results to check that intended benefits are being realised and that actions and results match the organisations environment.

IX. Differentiate between operation and process. True improvement as evidenced from this study comes from what can be done to the processes or the system and not to the operations. For example it was shown than implementing an innovative segmented tooling for the PNC spinning workstation can substantial reduce manufacturing steps, costs, manpower requirement, lead time and improve the drive towards Just-In-Time manufacturing.

X. Embed lessons learned through training as well as by involving all stakeholders (in any case stakeholder consultation and involvement right from start - see II above).

XI. Start the next repeat cycle of improvement drive all over again. This will be most likely at a higher level of difficulty. Always ensure that sensitivity to environment and the political approach is at its heart, and always ensuring to use sensitively matched world-class tools of processes improvement such as SMED and small batch size.

Chapter 8

Conclusion

This research aimed to adopt a practical approach to continuous process improvement in an SME. The objectives achieved and the works carried out to achieve the particular objectives are listed below:

1. Full review of manufacturing, assembly process and, workflow plans for each product line. This was done by first capturing knowledge of the production process and then fine-tuning them.
2. Increased production output by 72% and reduced lead times from 5 weeks down to 10 weeks by implementing a range of process improvements such as Small Lot production and SMED.
3. Recommended capital equipment upgrade in order to gain operation improvement as well as capacity.
4. Developed standard times for in-house operations and accurate product costing. This was achieved by implementing the use of job cards, which was used to obtain average operation duration for each production task.
5. Formalised the case study company's current production process layouts.
6. Maximised shopfloor space by implementing good housekeeping, line balancing, capturing frequency of travel between workstations and then marking and painting the shopfloor space.
7. Formalised drawing process by organising a filing system and a database.
8. Conducted skill audit of manufacturing staff, which the case study company used for creating staff development plans and for capacity planning.
9. Integrated the process into the company's existing ISO accreditations.
10. Reduced stock levels by 50% through the successful implementation of Small Lot production method. The case study company estimated that it saved £5000 simply by paying less interest on stockholding as result of the small batch production method.
11. Carried out cost analysis of all products; this was made possible by the captured operation steps and their corresponding duration.

12. Reduced manufacturing costs by implementing the aforementioned process improvements such as SMED, line balancing and determination of true capacity, which reduced frequency of unnecessary overtime labour cost.
13. Improved workflow in manufacturing, and assembly by implementing line balancing, small batch manufacturing and proper synchronisation of manufacturing and assembly shopfloor activities. This was further helped by the developed and implemented in-house MRP, which made the task of generating purchase orders, batching up subassemblies and parts much less time consuming and error-prone.
14. Initiated culture change by instituting multi-skilling and development of operatives. This was further achieved by first studying the case study company's overall business process and implementing the resulting findings. For examples, regular cross functional meetings were instituted to promote communication and bonding. The meetings became avenues for seeking goal congruency and soliciting process improvement ideas.

As has been emphasized throughout this thesis, the above case study company's operational and process improvements achieved by this study were not just due to the use of techniques of continuous process improvement. Such improvements were achieved mostly as a result of mindset change in the organization by its crucial members. This mindset change was made possible by understanding the dynamics and limitations of power operating within the company (being sensitive to local sensibilities). Thus, the significance of this research has been to underscore some of the organisational, technical and knowledge constraints, which companies wishing to gain competitive edge must overcome.

In a wider context, the thesis has developed and demonstrated use of a methodology for achieving process improvement in an SME despite the limited resources and the resistance to change in the particular SME. The evidence of this study in conjunction with postulates of academic literature confirms that the established Production and Operations Manufacturing strategies can indeed be applied successfully to SMEs such as the case study company; however these strategies must be modified to suit local context.

This thesis has also demonstrated that the conceptual framework developed in this study is an effective approach to a continuous process improvement study. This framework and the lessons learnt from its use in this case study can be used as a launch pad for achieving improved process and competitive advantage by other SMEs.

The academic literatures dealing with the organisational politics can be found few and far between, and have not fully addressed some of the issues encountered in the case study company studied in this thesis. In 1970, Olsen presented a thesis which showed that power in an organization can come from sources other than position power (Olsen, 1970). Others, such as Crozier, Pfeffer and Reiff demonstrated how a person's power or a subunit's power can be derived from the ability to perform functions, which others depend on such as special skill, ability to control information, dealing with uncertainty, etc. (Pfeffer, 1981a; Mintzberg, 1983; Crozier, 1964; Reiff, 1974). Furthermore, works such as (March and Simon, 1993) - first published in 1958, (Perrow, 1986), (March 1991), (Mintzberg, 1983), (Lee and Lawrence, 1991), (Lee and Lawrence, 1985) have helped a lot to articulate organizational politics. More recently, James Thompson and Blake Thurman raised the issue of how decision makers overcome the constraints of interdependence on their ability to exercise discretion in their paper "Two-step leverage: managing constraint in organisational politics" (Gargiulo, 1993). Kacmar and Ferris acknowledged the inevitability of politics in organizations and underscored the importance of allowing those affected by political behaviour to tell their own stories, so that the true ramifications of political activities might be discovered (Kacmar and Ferris, 1993). Also, Gerald Ferris and Michele Kacmar investigated the personal and situational factors that influence employees' perceptions of organizational politics (Ferris and Kacmar, 1992). A follow-up research by Christopher Parker, Robert Dipboye, and Stacy Jackson examined antecedents and consequences of politics perceptions and confirmed Ferris and Kacmar's previous theory that organizational politics are an important dimension of peoples' perception of their work environment. Patricia Wilson investigated the effects of politics and power on organisational commitment, especially the effects of these factors on the commitment of top executives in the public sector of USA

(Wilson, 1995b). Mastenbroek on the other hand considered the problems of sub-optimisation and resistance to change from the perspective of organizations as political networks (Mastenbroek, 1986).

On implementation framework suitable for the needs of small businesses, the paucity is a known problem in literature (Yusof and Aspinwall, 2000a) despite some brave attempts. For examples, Mazany presented a case study detailing lessons from the progressive implementation of just-in-time in a small knitwear manufacture (Mazany, 1995). Ong, studied productivity improvements for a small "made-to-order" manufacturing environment (Ong, 1997b). Wessel and Burcher presented Six sigma for small and medium-sized enterprises (Wessel and Burcher, 2004b).

So, what is new about the approach described in this thesis? Can the practical experiences of this study translate into academic lessons for future engineers, what can it contribute to the knowledge of researchers and practitioners?

Organisation politics is a topic that has not been paid much attention by engineers. It is often a subject usually studied at best as a minute part of Organisation Behaviour (OB), Management Studies, Sociology, Politics, etc. this is a surprise and represents a yawning gap in the knowledge of engineers especially those who must implement process improvements and other change projects. Politics is pervasive in organisations; in SMEs, it is not only pervasive, its indicators or manifestations (power and influence) are very visible and easily felt. Butcher and Clarke asked the question "Organisation politics: the missing discipline of management?" should politics be a "formal" management discipline? (Butcher and Clarke, 1999) In this thesis the question becomes is the knowledge of sensitivity to local sensibilities, which is obtainable via the study of organisation politics the missing gap in the training of academics and those who would implement process improvements in small to medium sized enterprises.

In what follows, contribution to knowledge will be presented.

8.1 Contribution to Knowledge

To the knowledge of the author, the literature gives little evidence of academic research materials on process improvement action research in SMEs having recognised that organisations are comprised of groups of people with diverse interest that normally compete but at the same time may cooperate on achieving organisation goals. Such a view about organisations is a political view comparing to the normal traditional managerialist views on organisations. None of the academic work reviewed by the author specifically addressed and linked the issue of organisation politics, and the requirement for sensitivity to local sensibilities, to the process improvement as required by the SME with little manufacturing experience. The practical, incremental application of process improvement, optimisation and manufacturing theories within the context of the political approach adopted in this thesis enabled the successful introduction of WCM tools in an environment where it may not have been possible.

The study developed and demonstrated empirically an effective action research methodology and an 11 step roadmap, which the researchers, academics, and practitioners of process improvement can utilise to navigate their way when they seek to help SMEs to get the most out of their scant resources; especially those in similar situation as the case study company, who had little manufacturing experience. The contribution to knowledge of the developed methodology can be summarized as follows:

1. The study confirmed that standardisation (to create repetitive, consistent process), process planning as well as through documenting, codifying, externalising knowledge can make significant impact to the overall improvements of a manufacturing company.
2. It also confirmed that resistance to change should be expected and that such resistance can emanate due to many reasons. But when it appears, knowledge of politics can be an effective remedy.
3. The study showed that incremental implementation is most suitable for SMEs lacking both resources and knowledge.

4. The study demonstrated alterative to stopwatch when measuring work whose content was previously unknown.
5. It demonstrated how to externalise tacit knowledge.
6. More importantly, it study has also practically demonstrated tools and templates, which researchers and others can use to optimise the manufacturing activities in situations similar to that of the case study company. These include combining the heuristics tools of politics with process improvement and manufacturing optimisation techniques.
7. Developed a conceptual framework for looking at the process improvement problem of an SME and proved its applicability.
8. It specifically addressed organisation politics, and linked the requirement for sensitivity to local sensibilities to process improvement as required by the SME with little manufacturing experience. Particularly, it is acknowledged that innovative use of WCM tools is not on the whole novel; also, a “mix and match” approach towards use of these tools has been tried before. Additionally, it is known that people make an organisation. However, in this thesis, it has been innovatively demonstrated that for companies in situations similar to that of the case study company, politics plays an important role and that there is a correlation between positive use of politics and successful implementation of process improvement measures. It has been shown that studying and understanding an organisation’s (SME) unique environment together with its politics, and then matching suitable WCM tools to it will bring success. Hence, this thesis has established a new empirical stage with sensitivity to local environment and politics as essential ingredients on which others can build upon and to understand how to implement process improvement and thus assist SMEs in situations similar to that, which the case study company previously was in.
9. Finally, the development of an **11-step road-map**, which other researchers, academics, process improvement specialists and interested companies can use to improve and optimise their processes. This was presented in the discussion session, chapter 7.

8.2 Limitations

Obviously, while SMEs can learn lessons from this study, there is a need to validate the results of this research by applying the lessons learned at other companies of similar size. The study was conducted in a period of economic boom; the company was experiencing an expanding market. It will also be necessary to check in a few years whether the case study company have been able to sustain the gains made as a result of this action research. It should however be noted that the study is not how an SME dealt with or survived economic recession but about how SMEs can practically apply incremental process improvement, optimisation and manufacturing theories. A few things planned in the framework did not work out very well in practice due to the case company's unique organisation environment. Quantitative measurement throughout the research period was difficult not only because of the nature of environment underscored in this paper but also due to sensitive and confidentiality nature of the information. The confidential nature of the project and the company's environment prevented excess to more quantitative data, which could have been used for more statistical analysis such as hypothesis testing. Also, it was not possible to rigidly follow the full PDSA cycle through. However, despite these limitations, this study has presented a new mechanism and empirical stage from which researchers and practitioners can launch future continuous improvement for SMEs.

8.3 Future work

Since heightened conflicts are inevitable in companies where scarcity of resources, less regulation and control exist (as can be found in a lot of SMEs), then it is to be expected that organisation's goals and decisions of such companies will emerge from bargaining, negotiating, and struggles by the members. In that case, process improvement must involve bending to local sensibility or "making do". There is a need for future work that would either support or dispute this findings and inferences.

Political behaviour can create an unethical and unhealthy work environment, and contribute to absenteeism, low morale and ill health. There is a need for more studies to examine the pervasiveness and ubiquity of Politics (good politics as well as skulduggery and unethical behaviour) in organisations. Plans are presently being made to widen this research and empirically test the framework beginning with SMEs in the developing countries of West Africa and eventually here in the UK.

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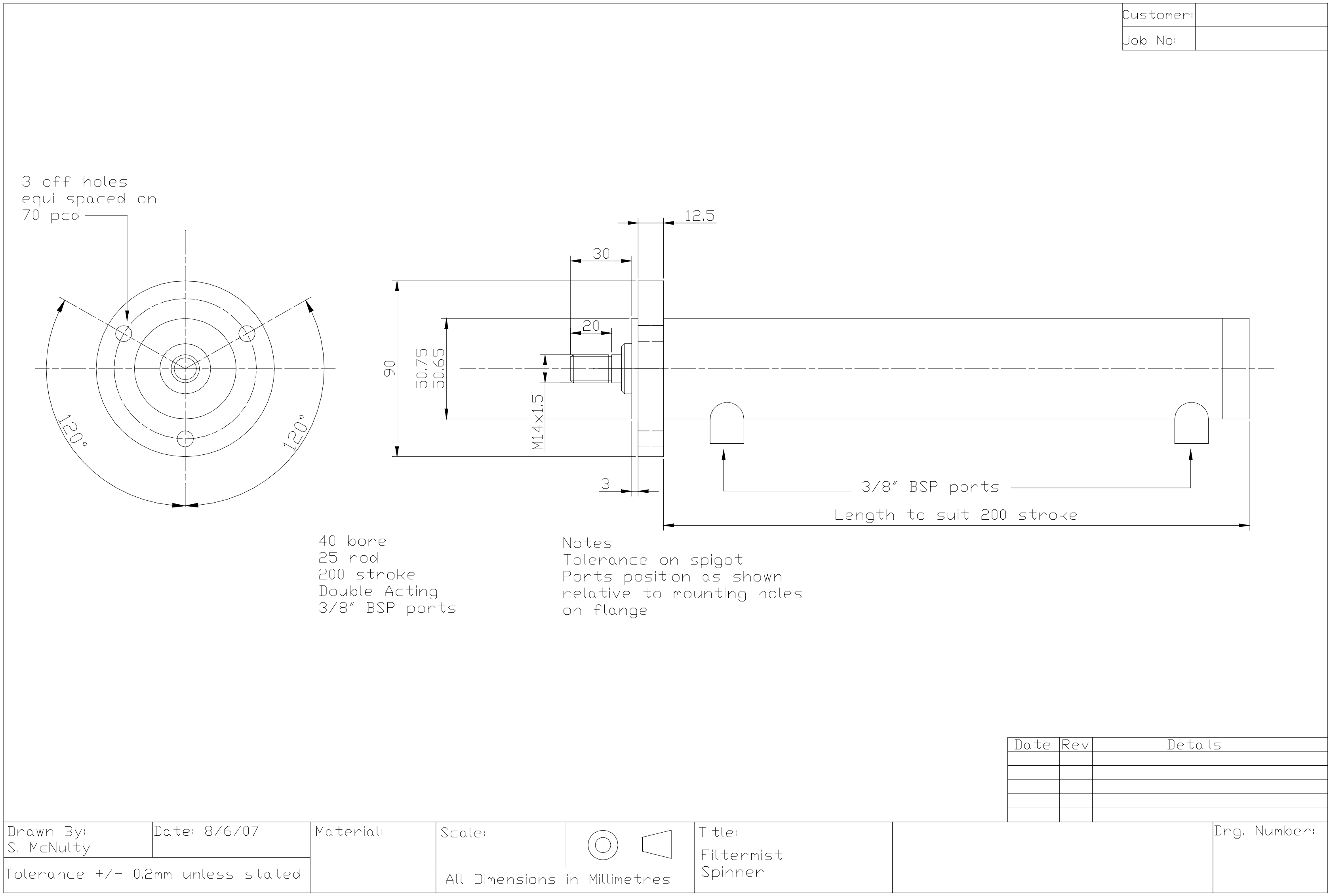
Appendix A: Published Papers

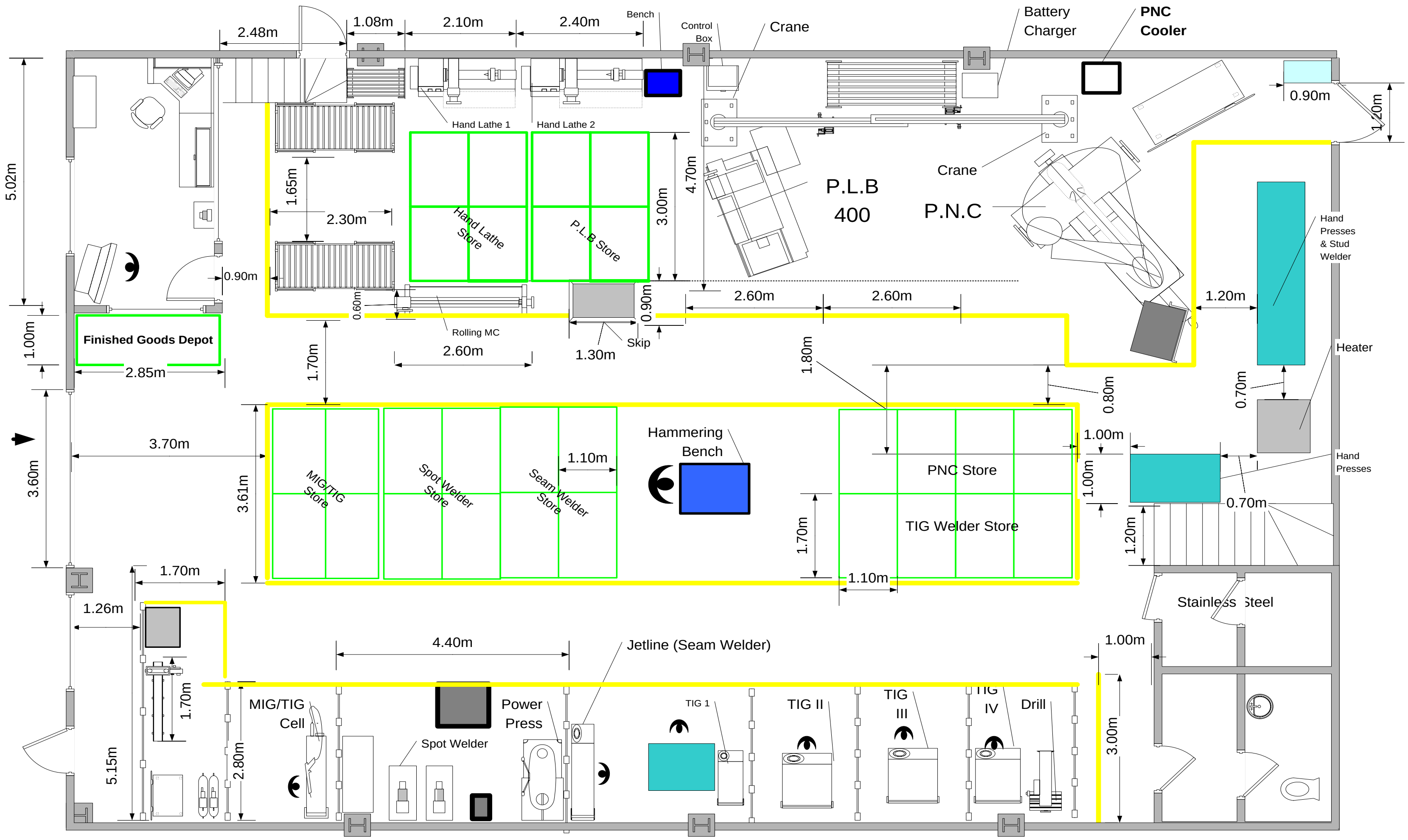
Papers published in the conference proceedings of Advances in Manufacturing Technology XXI. Proceedings of the 5th International Conference on Manufacturing Research (ICMR200*7), 11th - 13th September 2007-07-20; e*dited by Professor D. Stockton, Dr R. Khalil and Professor R. Baines. ISBN is 978-0-9556714

1. Onwunaje D and Oraifige I. (2007), "Instigating Business Process Improvement as a Foundation for Productivity Increase at a Small to Medium Sized Enterprise", *Proceedings of the 5th International Conference on Manufacturing Research (ICMR2007),* pp.153 - 157

2. Onwunaje D and Oraifige I. (2007),"Using lessons of Knowledge Management and Process Improvement tools to Increase Productivity at a small to Medium Sized Enterprise", *Proceedings of the 5th International Conference on Manufacturing Research (ICMR2007),* pp.158 -162.



Appendix B: CAD drawing for manufacturing the hydraulic ram



Appendix C: Plant layout drawing of manufacturing shopfloor used to facilitate painting and marking

Appendix D: Opinion Poll (questionnaire)